

# CHEMICAL & METALLURGICAL ENGINEERING

MAURICE A. KNIGHT

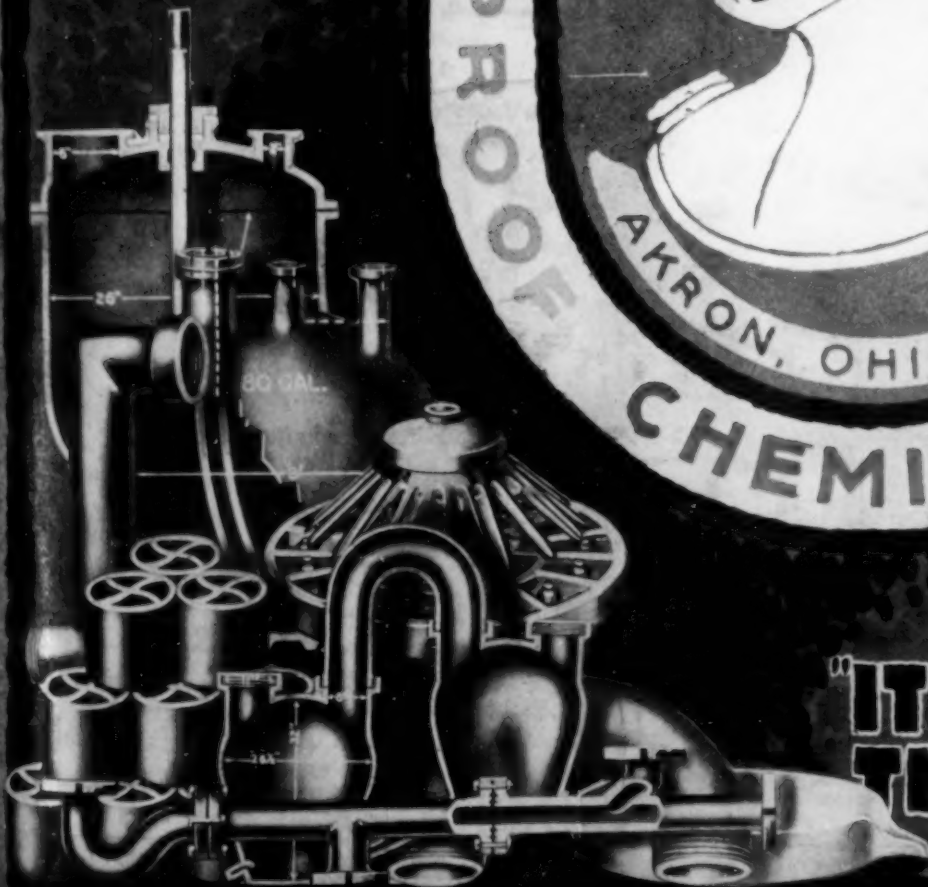
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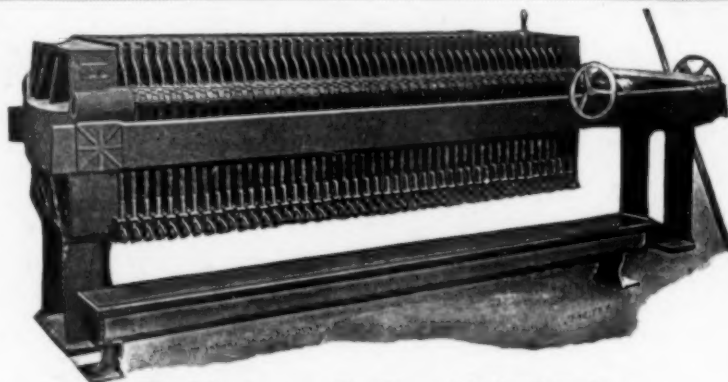
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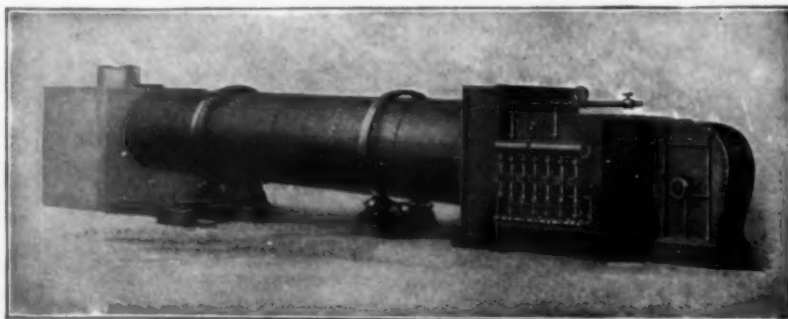
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# CHEMICAL & METALLURGICAL ENGINEERING

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### Speaking of Propaganda

ACCORDING to a time-honored custom, the dancers usually defray the expense of the orchestra. So Germany, having indulged in a wild orgy and frightful revelry for four years, is about to be presented with the bill; and signs are not lacking that she is looking furtively about for a side exit through which she may escape the collector. The whining press dispatches emanating from her political leaders urging justice and leniency on the part of the Allies, and even threatening dire consequences if the Peace Conference lays on too heavy an indemnity, are but palpable attempts to secure sympathy from thoughtless minds.

German propaganda is still in our midst—deceptive, insidious, baneful. It rears its head on the front page of the daily press, in whispered talk on the street and in published interviews with prominent personages. It is the most effective weapon left in the hands of an unchastened and unrepentant nation, and it can yet work untold harm unless intelligent people steel their hearts against it. In many respects it is unfortunate that Germany was not whipped into decisive military defeat, because that outcome might have chastened her pride and brought home a lively sense of the enormity of her crimes. Perhaps this desirable end may yet be accomplished when her people realize that the bill must be paid and that it is huge beyond the dreams of the indemnities which her own rulers had planned to exact from the Allies. No qualms of conscience or false spirit of magnanimity should deter those who are charged with fixing the terms of peace from exacting the last full measure of just reparation from Germany. Her land is unscarred by shot and shell; her factories and machinery are intact; her people have homes and will get food enough for subsistence; she has natural resources such as potash that can be administered in the interest of the Allies; her people are sufficiently accustomed to heavy taxation to warrant continuance of that means of securing national funds. In short, Germany is able to pay, and no amount of propaganda should swerve the Allies from the only course that will satisfy the great mass of their peoples.

### The Blight of Blatherskite Rule

EVERY issue of *Science* contains memoranda of the shift, by leading men, from the faculties of colleges and universities over to industry. Of the change from industrial work to the high estate of professorship there are very few notes. In the Employment Bureau



of the Chemists' Club there are constantly increasing applications for positions as chemists, but only a few applicants are even willing to teach, far less desirous of so doing. The exodus from teaching seems to be more particularly from the so-called freshwater institutions: the State colleges and the universities of interior States.

Now, teaching is the greatest of the arts, and while its emoluments are seldom high, many such posts offer opportunities for research, and also for consultation. Despite the incursions of dancing masters and sleight-of-hand performers, there still inheres a great dignity to the title of professor. What is the trouble, then? We answer, frankly, politics. Trustees are appointed who are without scholarship or educational ideals. They do not even know enough to keep their hands off what they do not understand. Sometimes a strong administrator in the person of the president can prevent them from meddling, but often again the trustees are too ignorant to forbear. They make life impossible for a conscientious educator.

The ideals of the majority of our State colleges and universities are splendid. The student bodies are no less than inspiring. They are eager to learn, and they lack the extra-academic "activities" which beset many of the Eastern institutions to the inhibition of serious study. The whole organization would be most promising, if it were not for a succession of dunderhead trustees appointed by the vagrant fancy of a series of transient Governors.

What these institutions lack is democracy at the top. Democracy implies working together, which is something the political trustees cannot understand. They strut about in their comedy authority, and insult professors and instructors; they make foolish demands, and they connive to replace useful and gifted teachers with their own relatives and friends. They interfere with discipline in the interest of grocers and haberdashers. A goodly number of them are infernal nuisances, for it is within the power of a single trustee to destroy the morale of a great institution.

We are disposed to favor a civil service commission to pass on all nominees for the trusteeship of colleges and universities that receive Federal aid, with the power to remove those who prove incompetent. The need for good instructors is pressing, very pressing, and many of the best are leaving their posts because of unendurable conditions, brought about by blatherskite rule!

### Metallurgy and Civilization

SAVANTS have pictured primitive man a beast of the jungle mouthing almost meaningless gibberings. Fortunately he discovered fire, and with this knowledge migrated into more temperate zones, where later with his new-found friends, a bow and arrow, he became hunter instead of hunted. Perhaps in this dim, uncertain eon the savage picked up yellow gold and white tin in the stream beds by which he penetrated the pathless forests, or found red copper in the ashes of a fire fortunately builded under boulders of ore. And in some way one found that white and red metal would melt together to form a different thing we now call bronze. When the savage learned that this new metal

could be made into superior tools and weapons he was a savage no longer.

Long millenniums of barbarism then passed, during which ancient man progressed mightily by virtue of his inherited wisdom. The making and the use of pottery in cooking reacted powerfully on his development; he changed from hunter to herdsman or farmer by the domestication of animals and the invention of irrigation. Yet the bronze age passed after ages of groping metallurgy, when the ancient smith produced steel in his primitive forge and discovered how to harden it after being cunningly wrought. Metallurgy had again opened the gates of civilization!

All this happened long before the invention of writing, and is known to us only by the remaining fragmentary handicraft of the ancient artisan. Recorded ideas now enabled man's culture to advance with increasing speed to but yesterday, when gunpowder and the printing press leveled society, physically and mentally. Perhaps the last great step toward the latest civilization has just been taken by Watt and his steam engine. But meager indeed would be our comforts had not the modern metallurgist responded to the need of huge quantities of cheap steel for bridges and ships, rails and boilers, of strong metals for axles and engines, of special alloys for electrical and domestic uses.

The word metallurgy images to many minds a small, dark, smoky, smelly iron foundry, or to others a high board fence surrounding furnaces glaring with white heat, and powerful machinery superhuman in power and dexterity. But in its entirety modern metallurgy influences our civilization down even to the commonest tools of life, and the initiated wonders to what state of savagery we would drop should it become a lost art.

### German Chemical Patents Take On New Aspects

THE Chemical Foundation, Inc., has recently been formed to take over the 4500 German chemical patents at present owned by enemy aliens. The charter of the corporation is so framed that under the patents non-exclusive licenses only can be granted on equal terms to all proper applicants and must be granted to the United States free of cost. By Executive order obtained under the provisions of the Act of Nov. 4, A. Mitchell Palmer, Alien Property Custodian, has sold to this company for the sum of \$250,000 all the German chemical patents which have been taken out in the United States.

It is well known that the German patents were not taken out to obtain exclusive manufacturing rights in this country, but to maintain exclusive sales. The sales departments of the various German companies feared Swiss, French and English competition and prevailed upon their manufacturing department to allow it to work out patent descriptions of processes which would protect their features but not disclose their actual methods of manufacture. As a matter of fact, the methods usually described were chosen for their excellently small yields. A mere sample of the product was all that was needed to fill the patent requirements and satisfy the sales department by furnishing it with a weapon to strike down competition.

Such an end to the mass of faked, camouflaged, false patents is as glorious as the victory in Europe. However,



the final success of the venture will require addition to the board of directors of men as eminent in the field of industrial science as the present members are in legal, executive and financial circles. The Chemical Foundation, Inc., will not be a commercial success unless it can supply manufacturing yield methods as well as patents. It cannot fail in doing some good in that it will prevent foreign competition on the commodities covered by its patents. Not having been formed for financial profit, vast sums of money will be collected and expended. Co-operation will be obtained to an extent not hitherto conceived, but men with a scientific insight should be in the pilot house as well as below the deck.

### **Sulphur Patents Are Decreed Invalid**

THE United States Circuit Court, sitting at Philadelphia, has dismissed the infringement suit of the Union Sulphur Co. vs. the Freeport-Texas Co. with the verdict that the patents lacked inventive substance.

Too many patents of doubtful validity are being issued which may or may not be of sufficient financial value to merit such a costly legal battle as has just been closed with the Frasch sulphur patents. While we are cleaning up the German patent system, can we not extend the good work and establish patent limits?

### **Deflating Prices Mobilizing Industry**

THROUGH the proposals of Secretary of Commerce Redfield war-time prices are to be deflated and industry is to be mobilized for normal peace-time activity. The principle of *laissez faire* is not to be allowed to obtain in the commodity markets. It is pointed out on behalf of the Industrial Board of the Department of Commerce, formed under Secretary Redfield's plan, with George N. Peek as chairman, that the law of supply and demand cannot be expected to cure what it did not create.

The condition of war-time control of prices, set at a high level in order to stimulate production, is not the only instance of the law of supply and demand not operating. It is a facile assumption that when prices are under control by pools or agreements among sellers, things interdicted by the Sherman law, the law of supply and demand is altogether suppressed, while when such agreements are suppressed the law of supply and demand operates. No more egregious blunder could be made. Time after time the iron and steel industry has given the plainest testimony that such is not the case. Repeatedly after a period of heavy buying and advancing prices it has, without agreement, held to existing prices neither because of agreement nor because of demand balancing supply, but merely and solely because the individual producers all recognized that to cut prices would be to precipitate a great decline, demand being too light to establish a price level only slightly lower than the existing one, and being certain, moreover, to be diminished rather than increased by price reductions. The mills had unfilled obligations with customers, and a break in the market would kill more of that tonnage than it would produce new tonnage. There was less to gain than to lose.

By and by the time arrived when the steel mills observed that there was more to gain than to lose by

giving prices a free rein. Bottom was then reached and the market eventually recovered, a new "buying movement" being inaugurated. Thus the endless cycle has been followed. If steel were not used for construction or "investment" purposes, if jobbers and manufacturing consumers pursued a rule of maintaining the same stocks at all times, and if mill deliveries against orders were made with the same degree of promptness at all times, prices of steel might fluctuate quite closely in accordance with the supply available and the actual consumptive demand. As it has been, the expressed demand exceeded at one time the actual consumptive demand and at other times fell short of it. Construction jobs were undertaken partly in a speculative spirit, being proceeded with not solely because the facility was needed at the particular time, neither sooner nor later, but because the buyer did not wish to overstay a rising market. Let us be thankful, therefore, that at last circumstances so clear and compelling have arisen as to force the admission that the law of supply and demand does not always set prices when the conspiracies in restraint of trade, interdicted by the Sherman law, do not exist.

There is no doubt that Secretary Redfield's Industrial Board will be able to accomplish some very good results. Judge Gary in his address to representatives of the iron and steel industry on March 6 referred to Mr. Redfield as "a very wise and thoughtful man," and Mr. Peek, chairman of the Industrial Board, who in turn addressed the meeting, impressed the manufacturers as being a man of true business instincts.

The board has two sources of power. In the first place, it can furnish assurance to a given industry that the co-operation of all industries will be sought for the purpose of securing the reduction in prices of building materials essential to the resumption of construction work. The brickmakers do not care to reduce prices if the steel producers do not, nor the steel producers if the cement makers do not, since for the full stimulation of construction work all items of cost should be reduced. Each industry, no doubt, would be willing to make its contribution if others would co-operate.

In the second place, the Industrial Board has the lever of Government or Government-controlled purchases. The Navy Department has considerable buying to do and some other Government departments have not a little, while there is a large volume of railroad buying that could be compassed if prices were made reasonably attractive.

To avoid possible disappointment, however, it should be recognized that the contemplated operation has its limitations. It cannot create an ideal condition on which years of industrial activity can be built. It does not know precisely how eager the investor will be to exchange "safe" investments, such as many bonds, for works of construction. It does not know precisely how hard workmen are going to be willing to work in future. It can develop a "recommended" price for merchant steel bars, perhaps even for screw stock and shafting, but must stop before it gets to farm implements, machine tools and automobiles. In particular, it seems to be the program to carry the activities, in establishing or re-establishing the law of supply and demand, only to the point of time when through decrease in the cost of living and other influences it will be fitting and proper that wages should decline. Wage declines, with fresh deflation of prices, will hardly be under Government auspices.

## Readers' Views and Comments

### Colloidal Condition of Silver Chloride

To the Editor of Chemical & Metallurgical Engineering

SIR:—Reading the editorial notes on Colloids in your issue of Oct. 15 made me recall an instance of what I suppose was a colloidal condition of silver chloride. This was encountered in laboratory control of the operation of a blast furnace that treated slag from reverberatory furnaces in which Lake copper concentrates were smelted.

In making determinations of the silver content of the impure copper ("cupola blocks") yielded by the blast furnace, it was noticed that at times the silver chloride, formed by adding HCl to the nitric solution of the copper, failed to settle out completely, even after one or more days of standing. Inspection of the records of such cases showed that they occurred uniformly whenever the blast furnace charge included, together with regular slag from the smelted concentrates, any considerable proportion of the slag that was formed from the reverberatory refining of "cupola blocks" themselves. I do not know whether any especial interest attaches to the foregoing, but offer it merely as an observation.

R. F. WOOD.

Sandusky, Ohio.

### The Analysis of Red Lead

To the Editor of Chemical & Metallurgical Engineering

Sir:—Soon after the publication of "Notes on the Analysis of Red Lead" in CHEMICAL & METALLURGICAL ENGINEERING, Jan. 1, 1919, my attention was called to "A Rapid Method for the Analysis of Red Lead and Orange Mineral" published in the *Journal of Industrial and Engineering Chemistry*, March, 1916. This is a hydrogen peroxide-potassium permanganate method and is said to be finding more and more favor with large users of red lead on account of its simplicity and accuracy.

As to its simplicity and easy adaptability to routine methods there is no question. However, I should simplify the details given in the paper referred to. There is no need of hot water or dilution and it is quite as simple to use a regular N/10 permanganate solution with a factor 0.03428 for the  $Pb_3O_4$ , as to use a computation based on an iron value of the permanganate.

As to the accuracy of the method, I have compared it on three samples of red lead with the iodide method, having standardized the permanganate with Bureau of Standards standard sodium oxalate and with ammonium ferrous sulphate. The sodium thiosulphate used in the iodide method was standardized with this permanganate. The samples were weighed with the same one-gram weight on the same balance and the titrations were made from the same section of a single burette at room temperatures not varying more than one degree during the analyses.

Sample I. By iodide, 92.55 and 92.55 per cent; by peroxide, 91.61, 91.32, 91.90, 91.63, 91.96 per cent. Average, 91.62 per cent.

Sample II. By iodide, 90.49 and 90.49 per cent;

by peroxide, 89.95, 89.71, 89.71, 90.15, 90.50 per cent. Average, 90 per cent.

Sample III. By iodide, 87.07 and 87.07 per cent; by peroxide, 87.74, 87.07, 87.41, 87.38, 86.81 per cent. Average, 87.30 per cent.

In the peroxide method the permanganate was measured in a second burette and two burette readings are necessary, while in the iodide method only one burette reading is taken and represents the iodine actually freed by the red lead and not a left over portion of a measured in amount of reagent. This probably accounts for the variations in the numbers for the peroxide method.

On the whole I should say the checks were as close as could be expected and sustain the claim for simplicity and accuracy.

W. F. EDWARDS.

Detroit, Michigan.

### Economics in the Zinc Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—I hope that the discussion caused by your recent publications on zinc metallurgy may lead to tangible results, and not to the usual very general and non-committal statements. Unfortunately for the writer, as is doubtless the case with numerous others, the invitation to participate in such discussion should really come from the metallurgist's superiors, and will be lacking in most instances.

It has been my experience that the capital which is backing the zinc smelters will not permit very radical changes unless the chances for success are good, and therefore I believe that the near future will show only gradual improvements. The vertical retort with continuous charging is likely to be the first effort of our industry not only to improve the retorting practice now in vogue, but also to overcome the labor shortage on the one hand and the growing inefficiency of labor on the other.

Roasting of zinc ores will, in my opinion, continue and should most certainly be accompanied by the extraction of sulphuric acid. However, the roasting process itself is in almost greater need of radical improvement than is the smelting. There is really no entirely efficient and satisfactory roaster in existence today, especially for the flotation concentrates, which will presently be the only type of ore we are asked to smelt.

Briquetting of furnace charges has been tried again and again, but in spite of its obvious advantages has not been worked out to a definite success. The large amount of air which is invariably present with briquetted charges appears to be the greatest drawback in retorting, and we may have to use a combination of briquets and the usual fine retort charge to reduce the voids.

The greatest difficulty in the retorting of zinc ores is still the condensation of the metallic fumes, and practically no progress has been made in improving the existing condensers, or in designing a new type.



The often disagreeable working conditions, the presence of excessive heat and obnoxious fumes, and the great physical effort now required, must be overcome to make the future zinc smelter a place to which labor will be attracted. We will have to get away from the methods of producing zinc by the spoonful, and must develop apparatus which will yield the best metallurgical results possible, combined with the lowest amount of labor needed, and at the same time take the responsibility for the finer points in our art out of the hands of practically trained labor, and vest it in the metallurgist, as is customary in the smelting of iron and copper.

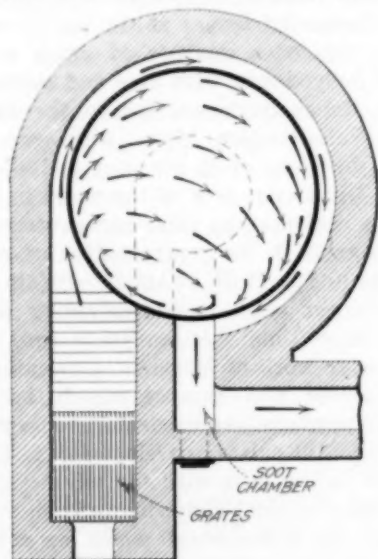
ZINC SMELTER.

### Furnace Settings for Caustic Pots

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to my article, "Furnace Settings for Caustic Pots," which appeared in your Jan. 15 issue, please note that the words "counter-current economizer" in the caption under the title should have been omitted. As stated in the text on page 67, particularly in the claim quoted from my patent, the liquor in the pot is caused to rotate by means of the tangential application of the products of combustion to the exterior of the pot, the direction of travel being concurrent with the rotation of the liquor.

Also, you will note that the arrows, indicating the direction of the liquor rotation in the right-hand pot in Fig. 3, page 65, were inadvertently pointed in the



CIRCULATION OF LIQUOR IN NICKLE TANGENTIAL DUTCH OVEN

wrong direction. This probably accounts for the use of the words "counter-current" referred to above.

My theory, as to why the natural rotative circulation of the liquor is concurrent rather than counter-current with the heating gases, is illustrated in Fig. 1. The heating surface adjacent to the combustion chamber is subjected to the most intense heat, whereas the reverse is true at the end of the circumferential travel of the heating gases or adjacent to the soot chamber.

Starting with a pot of cold liquor, the two temperature extremes being in close proximity, it is evident that convection or eddy currents will be set up in the liquor, the direction of which will be clockwise as indi-

cated. Gradually the cold particles of liquor, remote from the high temperature heating surface, come within the influence of these eddy currents until the arcuated path of active circulation is established tangentially to the orbital heating surface, and in substantially a horizontal direction with reference to arcs struck about the axis of the pot, the rotation being in the direction of decreasing application of heat, or concurrent with the travel of the heating gases.

Saginaw, W. S., Mich.

FRANK H. NICKLE.

### Novel Method for Treating Sulphur Ore

To the Editor of Chemical & Metallurgical Engineering

SIR:—The war stimulus to the sulphur mining industry resulted in the serious attempt to develop and operate numerous Western sulphur deposits, mostly of solfataric origin and not adapted to the application of the celebrated Frasch underground liquation process to the problem of the recovery of the native sulphur from the gangue with which it is associated. Heretofore the method in use in this country was the liquation process, using the principle of melting or liquefying the sulphur in a closed chamber or retort by means of superheated steam and the recovery of the sulphur by simple drainage methods. This apparatus in any of the forms used was expensive to operate and the recovery of the sulphur was very low, sometimes not more than 25 per cent; besides it was costly in operation and very uncertain as to results under the varying physical conditions of the material to be treated. Several mechanical adaptations of this method have been resorted to, but in general the process is a very imperfect one from the standards of cost and efficiency.

Attempts to recover the sulphur by flotation have been made in the laboratory and by means of experimental plants, and there is promise of very good results in this line. However, the problem has engaged the attention of a number of operators, with the result that some novel metallurgical ideas have been evolved, at least to the experimental stage. One of these is based on the familiar "shot-tower" idea. The sulphur with the gangue is submitted to treatment under pressure by superheated steam, with the result that the sulphur is liquated and drains through the perforated bottom of the retort along with more or less of the fine gangue and dirt, the separation of which from the liquid sulphur is one of the problems of other liquation applications. In falling a short distance, not more than 10 ft., the sulphur forms small spheres in a similar manner to the action of the streams of molten lead in the shot tower, and at the bottom of the chamber there is accumulated a mixture of these "shots" and the fine material. The sulphur "shots" are very pure and free from dirt and fine rock. Their further separation is an easy matter of screening and separation by methods familiar in other applications. This novel metallurgical idea is being tried out in an experimental way in Chicago, and patents have been applied for.

It is interesting to consider whether the idea might have application to any other metallurgical operations and whether its possibilities in the sulphur field are of importance.

KIRBY THOMAS.

New York City.

## Twenty-First Annual Meeting of the Canadian Mining Institute

Report of Business and Technical Sessions, With Special Reference to the Production of Such War Minerals as Manganese, Platinum, Chromite and Molybdenite—National Research and International Co-operation—D. H. McDougall Elected President

THE Canadian Mining Institute celebrated the attainment of its majority at the annual meeting held in Montreal, March 5-7, 1919. In his opening address President D. B. DOWLING referred to the cordial and friendly relations existing between the Canadian and American mining engineers, as evidenced by the exchange of visits at the annual meetings of the respective societies. This practice has been growing in recent years and should become an established custom. It was again referred to by MR. H. V. WINCHELL, president of the A. I. M. E., who spoke on the subject of international co-operation in mining, and who advocated intermingling of Canadian and American mining engineers as an effective measure for making imaginary boundary lines non-existent except for political purposes.

President DOWLING reviewed the assets of Canada and said that her economic aim should be to develop her natural resources and thereby improve her local markets. Canada's products should be offered to the world in manufactured form whenever possible; and he placed on mining engineers the responsibility of developing in the highest degree the mineral resources of the Dominion.

### CHANGE OF NAME PROPOSED

At the annual business meeting the Institute became involved in a long discussion over DR. STANSFIELD'S resolution to change the name from Canadian Mining Institute to Canadian Institute of Mining and Metallurgy. Difference of opinion centered mainly in the function of the Institute—whether it was devoted to the general industry of mining without regard to the different phases, such as mining, metallurgy, geology and chemistry, or whether it was a professional body concerned with the technology of methods and processes. Discussion seemed to favor the former view, i.e., that the Institute is devoted to the mining industry as a whole and is not primarily a technical organization. DR. STANSFIELD'S resolution was disposed of by referring it to the membership at large for letter ballot.

Certain amendments to the by-laws were proposed and referred to the membership. One related to classification of membership, introducing the grade of "professional member"; and the other was concerned with the election of officers and council. The purpose of establishing "professional members" was the convenience of council in dealing with other engineering bodies in Canada on subjects involving the professional status of mining engineers. The object of the amendment relating to officers and council was to provide machinery whereby the Institute would be in closer touch with the interests of the provinces. It calls for

an increase in the number of vice-presidents from four to six; the redistricting of the Dominion into six districts which shall have direct and equal representation on council.

The question of the salaries received by technical employees in the civil service of the dominion and provincial governments was discussed at some length, and finally the Institute passed a resolution urging the Government to provide larger salaries for its officials and employees whose duties call for technical training.

MR. D. H. MCDUGALL, president of the Nova Scotia Steel & Coal Co., was elected president of the Institute for the ensuing year.

### SYMPOSIUM ON MOLYBDENUM AND CHROMIUM

Several papers were scheduled dealing with the mining, concentration and metallurgy of molybdenum and chromium ores. MR. B. C. LAMBLE described the manufacture of ferromolybdenum at Orillia, by smelting in the electric furnace a mixture of green or raw concentrates of molybdenite with lime and carbon. Eighty per cent of the molybdenum fed to the furnace was recovered. Volatilization losses were very low, but there was a dust loss of 11 per cent and a slag loss of 7 per cent. Ninety per cent of the metal in the latter, however, was recovered by table concentration.

Recent progress in the concentration of molybdenite was discussed by MR. H. H. CLAUDET. He cited Elmore's successful pioneer work in concentrating molybdenite by flotation more than thirteen years ago, and he reviewed the later work of Wood in developing the film-flotation machine and process which had been so successful in producing molybdenum concentrates during the war. Still a later development was the application of the Callow cells with the adjunct of a screen to separate the flocculent molybdenite from the granular silica pyrite. In a flow-sheet which he exhibited the ground ore was first floated in a rougher cell which yielded a finished tailing and a dirty concentrate, the latter being cleaned in a second cell. The second tailing was returned to the rougher cell because it was quite rich in molybdenite. The concentrate contained some pyrite and silica, and these were separated by passing the concentrate over a Callow traveling-belt screen. The molybdenite formed flocks which remained on the screen and were readily separated from the impurities which passed through. This latter product was returned to the rougher cell on account of its high molybdenum content, and ultimately the silica and pyrite would go out with the cell tailing, while the molybdenite would flocculate and be caught on the screen. This method effected a 95 per cent recovery in a concentrate containing 90 per cent  $\text{MoS}_2$ . The utility of screening



was shown in raising the grade of a 3 per cent MoS, flotation concentrate to 65 per cent, and one of 12 per cent to 76. In discussion it was brought out that soluble sulphates interfered with the process, as also did chalcopyrite. Mica was not objectionable unless present in large amounts. Oxidized ores of molybdenum did not yield well.

New occurrences of chromite in Canada were described by DR. ROBERT HARVIE in an illustrated lecture; and the concentration of chromite was the subject of a paper by MR. L. K. FLETCHER. Discussion elucidated the fact that Canadian chromite could be produced and sold at a profit for \$1 per unit in 50 per cent concentrate, as against the quoted price of \$1.75 per unit for the New Caledonian product. It would be essential, however, to have at least \$1 per unit for the domestic product in order to provide insurance against the irregular ore-bodies.

#### WAR-TIME SEARCH FOR PLATINUM AND MANGANESE

The lengths to which Canada went in an effort to secure adequate supplies of needed war minerals were well shown in an illustrated lecture by MR. G. C. MACKENZIE. He described his explorations on the Saskatchewan River and on the Tulameen in British Columbia, where large areas were prospected with hand augurs and with Empire and Keystone drills. Work on the Tulameen yielded results of 35c. per cu.yd. in gold and platinum, and was considered encouraging; but winter set in before drilling could be carried further, and the war ended before the winter was over. The area is still regarded as worth investigation by private concerns.

Manganese was sought on the Island of Vancouver and some deposits were found carrying from 30 to 50 per cent. The matter of making ferromanganese on the Canadian Pacific coast was investigated, and it was finally determined to be commercially impracticable on account of the cost of power. With ferromanganese selling at \$100 per ton in the Eastern metallurgical centers, and Western power costing 7 mills per kw.-hr., the scheme would not be feasible. Power at 2 mills would be necessary for success. Canada used 1000 tons of ferromanganese monthly during the war, and had to import all of it from the United States or Great Britain.

#### INTERNATIONAL CO-OPERATION IN THE MINING INDUSTRY

One day of the session was designated as American Institute Day, and was devoted to joint discussions relating to industrial relations, principles of taxation, co-operation among small concerns in the same district, etc. MR. H. C. PARMELEE outlined the changes that have been and are occurring in the relations between employer and employee, citing the most advanced customs among the leaders of industry in Europe and the United States. The subject of taxation was presented by MR. THOMAS W. GIBSON. SIR JOHN WILLISON spoke in advocacy of Government aid to the mining industry just as it is given to the agricultural or fishing industries. He approved the bounty for metal production and urged the participation of the Government in the development of the country through national industrial and scientific research. He thought that technical

societies should address themselves to the education of legislators in regard to research, and hold sessions at the capital while Parliament is in session so that members might attend some of the meetings. Special programs for the information of legislators would be an effective method of education.

#### THE PROBLEM OF NATIONAL RESEARCH

DR. A. P. MACALLUM of the National Advisory Research Council addressed the Institute on the functions of the Council, which are as follows: (a) The investigation of standards of weight, measure, volume, etc.; (b) standardization of technical and scientific apparatus; (c) standardization of raw materials and products of Canada used in the arts and industries; (d) improvement of technical processes; (e) research to promote the utilization of the natural resources of Canada; and (f) the encouragement of trade research associations, to be assisted by the Government with free quarters and expert advice. He regarded the last as the most important function of the Council because through the development of Canada's potential industries she would be enabled to meet her future debts, pensions, etc. His remarks were the subject of an adjourned meeting at which the policies and proposals of the Research Council were warmly discussed and finally made the subject of a resolution in which the C. M. I. council was directed to investigate the proposals of the Advisory Council of Scientific and Industrial Research and determine the advisability of the proposed procedure.

#### APPLYING POWDERED COAL IN BLAST FURNACES

A paper of unusual metallurgical interest was that of MR. W. L. WOTHERSPOON on the use of pulverized fuel in smelting copper-nickel ores in the blast furnaces. He reviewed the experiments started by the Tennessee Copper Co. and later by the International Nickel Co. The conditions at the two plants are essentially different, because the former has a charge consisting mainly of lump ore, while the latter uses 75 per cent of roasted ore that gives a screen analysis showing 53 per cent on 1½ in., 16 per cent on 1 in., and 31 per cent through 1 in. Tests now under way have been going on for more than two months and considerable economies in fuel consumption have been effected. The powdered coal is blown into the furnace through the tuyeres, the same grade of coal being used as for reverberatory firing. Plans are under way to apply the method to lead smelting. Mr. Wotherspoon's paper will be published in the *Transactions* of the C. M. I.

MR. E. J. CARLYLE described some special equipment that had been devised for a copper smelter in Russia. It consisted mainly in four-compartment charge cars, ore bins and smelting furnaces, designed to save time and labor as well as distribute the charge effective in the furnace. A feature of the furnace was a water-cooled cast blister-copper spout which was found necessary in order to resist the action of a very corrosive matte.

MR. W. FLEET ROBERTSON gave the results of an investigation of a hoisting cable which had failed in very light service. It was found that the exterior of the rope was sound and appeared to be in good condition, while at the same time spots in the interior were

badly corroded, thus weakening the rope. A method of electrical testing was devised, depending on measurement of the resistance of the rope every three or four feet. This was found effective in locating corroded spots. As a preventive against this corrosion it was recommended that periodically the rope be immersed in hot liquid grease, as the ordinary surface greasing was insufficient.

The meeting was marked by a number of social features, including a smoker and the annual banquet. At the former there was an exhibition of films showing Canadian forces in action in the Great War, as well as an illustrated lecture on General Allenby's campaign in Palestine, by DR. H. M. AMI. Two lectures on military tunneling and mining were given by MAJOR R. W. COULTHARD and CAPT. L. B. REYNOLDS. At the annual dinner the principal speech was made by the DUKE OF DEVONSHIRE, Governor-General of Canada. He lent official support to the project for industrial research and to Government aid for the mining industry. Not the least important of his remarks related to the unity of interest of the employer and the employee, and the necessity for generous and broad-minded treatment of our industrial problems. In this connection he saw a large duty devolving upon engineers.

## Report of Alien Property Custodian on the Chemical Industry

THE activities of the alien property custodian have been too extensive ever to be fully reported, but interesting reading is to be found in the voluminous report filed this week. Three of the Big Six German dye companies, Bayer, Berlin and Kalle, did not give Mr. Palmer much trouble, but the Badische, Hoechst and Cassella proved to be quite elusive. These latter concerns were nominally owned by Messrs. Kuttroff and Pickhardt; Herman A. Metz; and Matheson and Shaw; however, an actual German ownership existed in each case. The Cassella Company U. S. patent assignments were recorded, but the fact that Messrs. Matheson and Shaw immediately reassigned them to the parent German concern was a secret. As the National Aniline & Chemical Co. was dependent on these patents, the title to which was supposedly transferred to it by the recorded owners, it can be seen how interested the Germans might have continued to be in the new American Co. The Metz transfer will prove equally illuminating and we quote verbatim from Mr. Palmer's report:

### THE HOECHST COMPANY

The American branch of the great Hoechst Co. had for many years been conducted by Mr. Herman A. Metz. Prior to 1912, the New York corporation was known as H. A. Metz (Inc.), and a majority of its stock was always owned by the parent house. In that year the German company took over all but 10 shares of the minority stock which had previously stood in the name of Mr. Metz, leaving him the record owner of these 10, the only shares not held by them. At the same time the name of the New York corporation was changed to Farbwerke-Hoechst, so that the value of the good will might be firmly fixed in the German name. At about this time the anti-trust proceedings above referred to were commenced against these companies also. Mr. Metz settled for \$40,000 the suit commenced against his company, and proceeded to make strong representations to the German house to the effect that the stock ought to be owned by him so that it could no longer be asserted that the German house was no longer doing business in America. A prolonged negotiation ensued, the Germans being very reluctant to

make any change. At last in the summer of 1913 it was arranged that the 1990 shares held by the German concern should be transferred on the books to Mr. Metz; that in return he should execute a demand promissory note without interest for the sum of \$597,000; that the note should be delivered to the German company, and the stock, together with a suitable transfer properly executed, should be deposited to the sole order of the German concern in a Montreal bank, as security for the note.

### HOW PROFITS WERE DIVIDED

At this time and for many years previous the American company had been operating under a contract by which the German house appointed it its sole American sales agent and agreed to furnish it with goods, in return for which the profits were to be divided according to an arbitrary scale, irrespective of stock ownership. Under this arrangement the Germans were to have one-half the profits of the color business and 75 per cent of the profits of the pharmaceutical business, which, owing to the development of salvarsan and novocaine, had become of great importance. In return, and as a check on possible overcharges by the German house, Mr. Metz was to receive a percentage of their profits on the sales to the American company. An irrevocable power of attorney was given to Mr. Metz to vote the stock owned by the German company in the New York house and an option was reserved to the German company to purchase the stock in the event of Mr. Metz's death or retirement.

### PROFITS SENT TO GERMANY AS LONG AS MONEY COULD BE REMITTED

This contract was continued unaltered after the stock transaction of 1913, and under it the profits were divided as long as it was possible to remit moneys to Germany. There was also an oral understanding between the parties that the note should not be payable except out of the stock or its proceeds, and that it could not be demanded as long as Mr. Metz should remain president of the company. It will thus be seen that the whole stock dealing produced no change whatever upon the rights of the parties. After it, as before, the share in the profits of each party remained the same; power to secure and pass title to the certificates remained as before in the hands of the German company alone; the voting power remained as before in Mr. Metz's hands; in fact none of the incident of ownership was in any way affected by the transaction.

At the outset Mr. Metz filed reports stating the existence of the note and the fact that certain stock was deposited as security for the same, but it was not until the ascertainment of the entire history of the transaction that the proof could be obtained that the transfer was not and was not intended to be of any effect. At last, however, the investigation thoroughly demonstrated this, and the stock has accordingly been taken over by me.

The Roessler & Hasslacher Chemical Co. people were equally unsuccessful in making a camouflaged American ownership title through the lawyer Oscar R. Seitz.

### PHARMACEUTICAL HOUSE OF E. MERCK

Another portion of the report says:

In pharmaceuticals, the most important concern in the world was that of E. Merck, of Darmstadt. This was represented in this country by Merck & Co., a New York corporation which had an enormous and very profitable business in all kinds of medicinal preparations. The stock of this company appeared on the books to be owned exclusively by George Merck, a member of the family which owns the house of E. Merck, of Darmstadt. Investigation, however, showed that the profits of this company had always been remitted to the German house in a manner utterly inconsistent with the apparent stock ownership, and it now stands admitted that the stock was paid for with money of the German house and belongs to the latter. Mr. George Merck insists that he is the real owner of one-fifth of this stock by virtue of the fact that he owns 20 per cent interest in E. Merck, of Darmstadt. I am of the opinion, however, that indirect ownership of this kind cannot be recognized under the trading with the enemy act, and I have therefore determined that the whole of this stock is enemy owned and it has accordingly been taken over.



As there has been 35,400 properties taken over, the estimated value of which is \$700,000,000, no attempt will be made to catalogue them. Next in importance and interest will be the action taken with the German owned patents.

#### CHEMICAL FOUNDATION, INC.

Mr. Palmer explains the German patent transaction as follows:

The idea was accordingly conceived that if the German chemical patents could be placed in the hands of any American institution strong enough to protect them, a real obstacle might be opposed to German importation after the war, and at the same time the American industry might be freed from the prohibition enforced by the patents against the manufacture of the most valuable dyestuffs. Accordingly, these considerations were laid before various associations of chemical manufacturers, notably the Dye Institute and the American Manufacturing Chemists' Association. The suggestion was met with an instantaneous and enthusiastic approval, and as a result a corporation has been organized to be known as the Chemical Foundation (Inc.) in which practically every important American manufacturer will be a stockholder, the purpose of which is to acquire by purchase these German patents and to hold them as a trustee for American industry, "for the Americanization of such institutions as may be affected thereby, for the exclusion or elimination of alien interests hostile or detrimental to the said industries and for the advancement of chemical and allied science and industry in the United States."

#### STOCK IN A VOTING TRUST

The voting stock is to be placed in a voting trust of which the trustees are to be the five gentlemen who for months have been acting as the sales committee which passes upon sales made by my department, that is to say, George L. Ingraham (former presiding justice of the appellate division, first department, New York Supreme Court); Otto T. Bannard (president, New York Trust Co.); Cleveland H. Dodge; Benjamin H. Griswold (senior partner of Brown Bros., bankers, Philadelphia); Ralph Stone (president, Detroit Trust Co.), and the charter is so framed that under the patents non-exclusive licenses only can be granted on equal terms to all proper applicants, and must be granted to the United States free of cost.

The company is capitalized at \$500,000, of which \$400,000 is to be 6 per cent cumulative preferred stock and \$100,000 common stock, also limited to 6 per cent dividends. The first president of the Chemical Foundation (Inc.) will be Francis P. Garvan, of the New York bar, to whose clear vision and indefatigable industry I am chiefly indebted in the working out of this plan.

#### COMPANY HAS 4500 PATENTS

By Executive order obtained under the provisions of the act, I have sold to this company for the sum of \$250,000 approximately 4500 patents; the remaining \$250,000 has been provided for working capital so that the company may be able to commence immediately and prosecute with the utmost vigor infringement proceedings whenever the first German attempt shall hereafter be made to import into this country. The charter of the corporation provides that surplus income is to be used for the retirement of the preferred stock and thereafter for the advancement of chemical and allied science and industry.

The price thus paid was necessarily determined somewhat arbitrarily; the great majority of the patents were presumably valueless. The value of the remainder was entirely problematical and impossible to estimate. Substantially the entire industry having combined for the purpose of this purchase, it would have been impossible on public sale to find as a bidder any legitimate manufacturer. No other bidder could, therefore, have been found on public sale except some speculative individual who might have bought them for purposes practically amounting to commercial blackmail. The combination was not objectionable to public policy since it was so organized that any genuine American, whether a stockholder of the company or not, could secure the benefits of the patents on fair and equal terms.

## Fate of the Water-Power Bill

The proposed water-power legislation which has been before Congress for the seven years of the present administration failed of passage when Congress expired March 4. After lengthy debate in committee and on the floor of both houses, conferees on the part of the House and the Senate agreed to report the bill favorably and it would undoubtedly have passed both houses if it could have been reached on the calendar. The proposed legislation did pass the House of Representatives a few days before the end of Congress by vote of 264 to 65, but failed to pass in the Senate, because it became entangled in the meshes of the filibuster which was conducted by Senators opposed to the President's policy in foreign affairs. Although there were informal assurances to Senators who had charge of the proposed legislation that there were at least 80 votes in favor of the measure in case it could be brought before the Senate, the bill did not obtain a hearing.

It will now be necessary for the advocates of water-power legislation to begin a campaign of education for the benefit of the new members of the House of Representatives and the new members of the Senate who are to take their seats in any proposed extra session of Congress which the President may call. Committee assignments which will have to do with water-power legislation will be altered under the organization of the coming Congress. The legislation, which has been in the hands of Democratic leaders in the House, will now be in charge of Republican leaders, inasmuch as the Republicans have control of the new House.

## "American Welding Society" to Be Organized

A meeting at the Engineering Societies Building, New York, will be held March 28, 1919, at 10:30 A. M. to effect the organization of the "American Welding Society." It is planned to replace the Welding Committee of the Fleet Corporation and the National Welding Council, and by contributing memberships represent the manufacturers and users of welding equipment and products. Other engineering societies will be invited to participate in such a way that the American Welding Society will become a common section to consider such problems rather than a separate technical organization. To the welding public it hopes to become a dependable source of information, and, granted the necessary support, to pursue various desirable investigations in an impartial manner.

## German Requisitions in Poland

The following table taken from the official reports of the German Central War Bureau shows some of the requisitions of the Germans in Poland during the period August, 1915, to the end of 1917, i.e., not including the year 1918, when all their sources were exhausted and when in the latter part of that year they were forced to leave the country and became more unscrupulous than ever:

	Tons		Tons
Metals (among them 7,000 of copper and 910 tons of steel cable).....	18,140	Rubber.....	400
Iron.....	24,292	Asbestos.....	105
Prepared leather.....	1,718	Varnish and oil colors.....	14
Tanned leather.....	6,500	Tallow.....	221
Leather belting.....	754	Commercial tallow.....	171
Fat, oils, animal fats, etc.....	1,055	Mucilage.....	215
Oil grains.....	4,307	Glycerine.....	40
Oil cakes (poppycakes).....	229	Soap.....	80
		Raw resin.....	962
		Chemical products.....	4,168

## Magnetic Concentration of Pyrrhotite Ores\*

Experiments and Tests Made With a Wetherill Type Magnetic Separator on Pyrrhotite Ore—No Classification Necessary, but Should Be Stage Crushed to Unlock the Sulphides From the Gangue—Costs, Low—Quality, Satisfactory

By J. P. BONARDI

Assistant Chemist, Bureau of Mines

**P**YRRHOTITE ores have been utilized in the United States for the production of sulphur in the manufacture of sulphuric acid, and when the resulting cinder was sufficiently high in iron and free from objectionable substances it was employed directly in the manufacture of iron. Since the war, the importance of increasing all available sources of material going into acid production has brought pyrrhotite ores and methods of their concentration to the attention of the U. S. Bureau of Mines. The use of pyrrhotite ores in the past was limited, in that a high-grade ore or product was required and also one freed from those gangue substances which would cause trouble subsequently in the sulphur burners, and later would cause the cinder to become penalized in its use for iron smelting. This fact necessitated concentration of some sort, and when hand sorting was resorted to, considerable amount of sulphur-bearing rock was discarded, thus curtailing production and increasing the mining cost.

It was while investigating the pyrrhotite deposits of southwestern Virginia that Mr. R. R. Hornor, of the U. S. Bureau of Mines, observed that much of the ore contained 20 to 30 per cent gangue material, composed chiefly of granular silica and magnesia and lime bysilicates of the amphibole group, together with black mica. The presence of these impurities is objectionable in material for sulphuric acid manufacture for the following reasons:

1. They lower the sulphur content, and considerable quantity of the ore is discarded which will contain around 20 per cent sulphur, thus curtailing production and increasing the mining cost.
2. The capacity of the roasting furnaces is reduced by the quantity of inert material contained in the ore treated.
3. The lime and magnesia present, upon roasting, form sulphates of these minerals and thus reduce the quantity of sulphur available for acid making.
4. The impurities reduce the iron content of the resulting cinder, and also make it less desirable for iron furnaces.

### MAGNETIC CONCENTRATION SUGGESTED

It was suggested that the quality of ores containing these objectionable impurities might be very much improved by eliminating a large part of the impurities by some method of concentration; and, therefore, magnetic concentration has suggested itself as possibly the most suited for the purpose, owing to the slightly magnetic properties of the pyrrhotite, and also since the methods which would be employed to prepare the ore

for roasting, namely, dry crushing and screening, would obviously leave the material in an ideal condition for magnetic separation.

In accordance with the program of increasing all available sources of sulphur material, it was suggested to the General Chemical Co. of Pulaski, Virginia, producer and refiner of pyrrhotite ores, that it ship large samples of its pyrrhotite material to the Rocky Mountain Station of the U. S. Bureau of Mines for investigation. Two samples of ore were received at this station. One sack consisted of ready crushed material, such as the General Chemical Co. is using at the present time in its roasting furnaces, that is, ore from the finished product bins; the other consisted of large lump size discarded ore from the company's mines.

The following data comprise work done, first, upon the discarded ore, and, second, on the finished product such as the company is now roasting, the object being, in both cases, to attempt to overcome some of the difficulties as outlined above by eliminating the gangue material, and to produce a high-grade concentrate of iron and sulphur from the discarded ore and also from the finished product material. The gangue material in both samples consisted of amphiboles, quartz and biotite.

### DISCARD ORE FROM THE MINE—PART I

The discarded ore as received in large lumps was crushed and finished off in a small "coffee mill" so as to stage crush all material through a 10-mesh screen. A screen analysis of this product through the 10-mesh gave the following results:

—10+20.....	28.60 per cent
—20+40.....	34.30 per cent
—40+80.....	21.00 per cent
—80.....	16.10 per cent
	100.00 per cent

Since the material was to be submitted for dry magnetic separation, fine grinding was to be avoided as much as possible, as the screen analysis indicates. It has been found by previous work on magnetic separation on roasted pyrite and pyrrhotite material that no practical concentration could be made on screened material which passed through a 100-mesh sieve. When the proper amperage was found which would render the coarse sizes below 100-mesh magnetic, and produce a proper concentrate with the required concentration ratio, it would, when applied to the finer sizes, render them practically totally magnetic; that is, 90 per cent or more, thus effecting no practical concentration of the values, when a concentration ratio of, say, 2 to 1 was desired in order to produce a high-grade product and recovery. This was due to the fact that on such fine ma-

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terial the magnetic portion would carry off mechanically the non-magnetic fine gangue material.

Five runs were made upon the discarded material, using an experimental type Wetherill magnetic separator having a 6-in. belt and two double pole magnets. One run was made on each of the four screened sized products, and one on the unclassified material as ground, without any sizing, but stage crushed through a 10-mesh.

An analysis of the discard ore, as received and prepared for analysis, gave the following analytical results:

S	19.50 per cent
Fe	33.45 per cent
Insoluble $\text{SiO}_2$	32.30 per cent
MgO	3.91 per cent
CaO and CuO	Small percentage

The composition of pyrrhotite is represented in text books by:

	$\text{Fe}_7\text{S}_8 + 1 \cdot \text{Fe}_3\text{S}_4$ to $\text{Fe}_{11}\text{S}_{12}$	
1. $\text{Fe}_7\text{S}_8$	S = 40.11 per cent	Fe.....59.89 per cent
2. $\text{Fe}_{11}\text{S}_{12}$	S = 38.51 per cent	Fe.....61.49 per cent

From the analysis of the discard ore, and considering the proportion of iron to sulphur in pure pyrrhotite, it would indicate that some iron exists in the ore in some other form than is combined in the form of pyrrhotite. Assuming that the total iron and sulphur together make up a magnetic product, there would be represented 52.95 per cent ( $33.45 + 19.50$ ) of the material magnetic, or a concentration ratio to be obtained for an ideal product of approximately 2 to 1.

### THREE AMPERE CURRENT ADOPTED

Qualitative runs were first made using different strengths of current by one-half ampere steps from 0.5 ampere to 5 amperes. This was tried on the unclassified material, as well as on the classified screened product, and the results indicated that amperage from 0.5 to 2 would take off only a small percentage of magnetic material. At 2 amperes, the magnetic product was found a little cleaner from gangue material than the product obtained at 2½ or 3 amperes, but the recovery was lower, since a considerable amount of pyrrhotite was still left behind in the non-magnetic tails. Three amperes was finally adopted as the best to employ on this experimental machine from the standpoint of economy and recoveries. At this amperage only a very small amount of gangue, principally biotite, would come off with the pyrrhotite. Higher amperage than 3 took off magnetically a considerable amount of gangue material with a small additional amount of pyrrhotite, which indicated that considerable gangue material was more susceptible to the magnetic forces than the very small amount of pyrrhotite which, in every case, was not attracted by the magnets. Undoubtedly, a slightly higher recovery could be obtained by employing a larger current than 3 amperes, but the grade of concentrate would be considerably lowered by more gangue matter being lifted off with the magnetic product.

The following table indicates the amount of material which was collected as non-magnetic on the different runs at 3 amperes:

Run	Size Stage crushed through 10-mesh	Amount Taken	Non-Magnetic	Per Cent Non-Magnetic	Per Cent Magnetic by Difference
I	—10+20	3000 g.	1420 g.	47.33	52.66
II	—20+40	2000 g.	980 g.	49.00	51.00
III	—40+80	2000 g.	900 g.	45.00	55.00
IV	—80	1000 g.	620 g.	62.00	38.00
V	—80	10	320 g.	32.00	68.00

An average of the amount of non-magnetic material in the first four runs would represent 49 per cent, or a magnetic product of 51 per cent, which approximates very closely to the amount as figured as magnetic from the chemical analysis of the iron and sulphur; that is, a concentration ratio of approximately 2 to 1. On the finer size, —80 mesh, 68 per cent would be rendered magnetic, but since this size represents only 16 per cent of the material, the amount of gangue taken off would not in any case prove very detrimental to the grade of concentrate made on unclassified feed; that is, material stage crushed through the 10-mesh.

The following tables represent the runs made; the recoveries are stated later in a separate table:

#### RUN I UNCLASSIFIED DISCARD ORE AS GROUND THROUGH 10-MESH

Sample	Weight in Grams	Per Cent Insoluble ( $\text{SiO}_2$ )	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	3000	32.30	33.45	19.50	3.91
Magnetic conc.	1440	5.00	55.85	32.85	1.08
Tails	1420	.....	10.85	4.94	.....
Mechanical loss	140	.....	.....	.....	.....

#### RUN II —10+20 MESH

Sample	Weight in Grams	Per Cent Insoluble ( $\text{SiO}_2$ )	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	2000	34.20	34.30	19.33	3.04
Magnetic conc.	990	5.20	56.40	32.75	1.34
Tails	980	.....	5.75	1.71	.....
Mechanical loss	30	.....	.....	.....	.....

#### RUN III —20+40 MESH

Sample	Weight in Grams	Per Cent Insoluble ( $\text{SiO}_2$ )	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	2000	29.70	37.80	20.80	3.15
Magnetic conc.	1065	2.90	60.80	33.80	0.18
Tails	900	.....	10.28	4.68	.....
Mechanical loss	35	.....	.....	.....	.....

#### RUN IV —40+80 MESH

Sample	Weight in Grams	Per Cent Insoluble ( $\text{SiO}_2$ )	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	1000	34.70	33.75	17.98	4.92
Magnetic conc.	380	3.60	58.08	34.25	0.58
Tails	620	.....	14.38	7.39	.....
Mechanical loss	.....	.....	.....	.....	.....

#### RUN V —80 MESH

Sample	Weight in Grams	Per Cent Insoluble ( $\text{SiO}_2$ )	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	1000	29.80	36.20	21.75	3.11
Magnetic conc.	650	19.80	40.40	26.25	3.22
Tails	320	.....	22.40	13.56	.....
Mechanical loss	30	.....	.....	.....	.....

In the above runs, the losses figured as mechanical can be calculated with the magnetic concentrates. This loss occurred at the hoppers in collecting the magnetic material. Whatever loss there was in weight, if any, in collecting the tail discharge would be due only to dust loss, which was of no consequence on the material treated. On continual commercial runs the mechanical losses could be practically eliminated.

In the following table of recoveries of sulphur and iron for the different runs, the basis of calculation was derived by the amount of sulphur and iron remaining in the tails divided by the amount of sulphur and iron going into the heads, which represented the per cent of sulphur and iron going into the tails; the difference between this per cent and 100 per cent gave the recovery of sulphur and iron going into the concentrate.

In calculating the per cent elimination of insoluble ( $\text{SiO}_2$ ) and MgO going into the non-magnetic tails, the per cent remaining in the magnetic concentrates was found (the mechanical loss was figured in as concentrates) and this per cent subtracted from 100 per cent,

giving the per cent of elimination of insoluble ( $\text{SiO}_2$ ) and magnesia ( $\text{MgO}$ ).

#### RECOVERY OF SULPHUR AND IRON IN MAGNETIC CONCENTRATES Elimination of Insoluble ( $\text{SiO}_2$ ) and Magnesia ( $\text{MgO}$ ) in Non-Magnetic Tails

Run	Per Cent Recovery of S	Per Cent Recovery of Fe	Per Cent Elimination of $\text{SiO}_2$	Per Cent Elimination of $\text{MgO}$
I Unclassified.....	88.00	84.65	91.84	84.10
II —10+20.....	95.67	91.77	82.24	77.55
III —20+40.....	89.64	87.75	89.75	97.94
IV —40+80.....	74.50	73.60	96.06	95.56
V —80.....	80.05	80.20	54.80	29.60

The percentage recovery of sulphur for classified feeds, as in runs II to V if the screen products were run separately as classified feeds, would effect a saving of 84.5 per cent.

The above results clearly indicate that the run made on the unclassified material compares favorably with the screen-classified runs. A slight additional gain in per cent of recovery of sulphur and iron would not in any case be sufficient to install or operate a system of screen classification. Therefore, no classification would be considered justifiable in treating this material on the Wetherill machine.

#### CONCLUSIONS OF RESULTS ON DISCARD ORE FROM THE MINE—PART I

1. A high-grade concentrate can be produced from the discard ore from the mine containing less than 7 per cent total of gangue material, consisting chiefly of insoluble matter with a small amount of magnesia oxide, giving a recovery between 85 and 90 per cent of the values sulphur and iron.

2. Approximately 90 per cent of the gangue material can be eliminated with the non-magnetic tails.

3. The concentration ratio between heads and concentrates is about 2 to 1.

#### FINISHED PRODUCT ORE—PART II

The following data comprise work done upon the ready crushed material or finished product which is being used at the present time in the roasting furnaces, the object of the tests being the same as given with the discarded ore, namely, to eliminate the gangue, since this material also has given some trouble in the sulphur burners in the past due to the same impurities as in the discarded ore, namely, amphibole silicates, quartz and biotite.

The material as received gave the following screen analysis:

+20.....	23.33 per cent
—20+40.....	34.66 per cent
—40+60.....	14.66 per cent
—60+100.....	11.66 per cent
—100.....	15.33 per cent
Loss.....	0.36 per cent
	100.00 per cent

An analysis of the material is as follows:

S.....	27.51	75.61 per cent
Fe.....	48.10	
Cu.....	Trace	24.39 per cent
$\text{Al}_2\text{O}_3$ .....	2.82	
$\text{SiO}_2$ .....	12.40	
$\text{CaO}$ .....	0.43	
$\text{MgO}$ .....	1.74	
Undetermined.....	7.00	
	100.00	

The material was tested for soluble sulphates or sulphur minerals other than sulphides by a sodium bicarbonate and an ammonium carbonate leach, and the results indicated none present.

The above sulphur of 27.51 per cent would then correspond to 41.10 per cent Fe in the first formula as given for pure pyrrhotite ( $\text{Fe}_7\text{S}_8$ ) and 43.90 per cent Fe in the second formula as given for pure pyrrhotite ( $\text{Fe}_{11}\text{S}_{12}$ ), thus indicating that in the material containing 48.10 per cent Fe there must exist some iron in the form of an oxide, which presumably can be calculated with the undetermined portion, or possibly gangue material associated with the other oxides and silicates. Considering the analysis, it is easy to ascertain that if the total iron and sulphur is calculated as being magnetic and the remaining elements as non-magnetic, there would be then represented 75.61 per cent magnetic and 24.39 per cent non-magnetic substances. It is safe to assume that a concentration ratio of approximately 10 to 7.5 will collect the iron and sulphur into a magnetic product with a good recovery.

The following table indicates the amount of material which was collected as non-magnetic on the different sized products at 3 to 5 amperes:

TABLE I.

Run and Amperage	Size	Amount Taken, G.	Non-Magnetic, G.	Per Cent Non-Magnetic	Per Cent Magnetic by Difference
I	3 amp. +20	2000	445	22.25	77.75
	5 amp. +20	2000	200	10.00	90.00
II	3 amp. —20+40	2000	750	37.50	62.50
	4 amp. —20+40	2000	215	9.95	90.05
III	3 amp. —40+60	1500	470	31.68	68.32
IV	3 amp. —60+100	1000	310	31.00	69.00
V	3 amp. —100	1500	70	4.67	95.33
and IX	4 amp. —100	500	10	2.00	98.00
VI	3 amp. Original material as received.....	3000	760	25.33	74.67
VII	3 amp. Original material as received.....	3000	895	29.86	70.12
VIII	3 amp. Material as received with —100 screened out.....	1200	335	27.90	72.10

From the above data, it is very apparent that 4 or 5 amperes current would be too large to employ, since on the coarse material (20-mesh) 10 per cent would remain non-magnetic, and on the —100-mesh material only 2 per cent would remain non-magnetic; both would be less than was calculated on the percentage of non-magnetic substance in the original material as received. A concentration ratio of 10 to 9 would prove insufficient to eliminate the gangue matter, so 3 amperes was then considered as probably the best to employ in most cases on the material as received and on the sized material, since this would give approximately the desired concentration ratio. In every case tried, 1 ampere proved insufficient, as only a slight amount was rendered magnetic. The following represents the runs made—the recoveries are stated in a separate table:

#### RUN I +20 MESH—AMOUNT TAKEN, 2000 G.

Head sample.....	Per Cent Sulphur
	30.85
Wt. of Products, Grams	
2 amperes.....	330
3 amperes.....	945
5 amperes.....	245
Non-magnetic (tails).....	200
Mechanical loss.....	280
	2000

#### RUN II —20+40 MESH—AMOUNT TAKEN, 2000 G.

Head sample.....	Per Cent Sulphur
	29.50
Wt. of Products, Grams	
1.5 amperes.....	295
2.0 amperes.....	580
3.0 amperes.....	400
4.0 amperes.....	510
Non-magnetic (tails).....	215
	2000



RUN III —40+60 MESH—AMOUNT TAKEN, 1500 G.

Head sample	Per Cent Sulphur
	27.30
Wt. of Products, Grams	
1.5 amperes	335
2.5 amperes	430
3.0 amperes	250
Non-magnetic (tails)	470
Mechanical loss	15
	1500

RUN IV —60+100 MESH—AMOUNT TAKEN, 1000 G.

Head sample	Per Cent Sulphur
	26.73
Wt. of Products, Grams	
1.5 amperes	210
2.5 amperes	210
3.0 amperes	245
Non-magnetic (tails)	310
Mechanical loss	25
	1000

RUN V —100 MESH—AMOUNT TAKEN, 1500 G.

Head sample	Per Cent Sulphur
	26.10
Wt. of Products, Grams	
2.0 amperes	850
3.0 amperes	290
Non-magnetic (tails)	70
Mechanical loss	290
	1500

RUN VI ORIGINAL MATERIAL AS RECEIVED—AMOUNT TAKEN, 3000 G.

Head sample	Per Cent Sulphur
	27.51
Wt. of Products, Grams	
1.5 amperes	750
2.5 amperes	960
3.0 amperes	415
Non-magnetic (tails)	760
Mechanical loss	115
	3000

RUN VII ORIGINAL MATERIAL AS RECEIVED—AMOUNT TAKEN, 3000 G.

Head sample	Per Cent Sulphur
	27.51
Wt. of Products, Grams	
3.0 amperes	2050
Non-magnetic (tails)	895
Mechanical loss	55
	3000

RUN VIII COMPOSITE SAMPLE (+20+40+60+100)—AMOUNT TAKEN, 1200 G.

Weights Proportioned Corresponding to Screen Analysis	
Head sample	Per Cent Sulphur
	27.88
Wt. of Products, Grams	
3.0 amperes	850
Non-magnetic (tails)	335
Mechanical loss	15
	1200

RUN IX (SAME AS RUN V) —100 MESH—AMOUNT TAKEN, 500 G.

Head sample	Per Cent Sulphur
	26.10
Wt. of Products, Grams	
2.0 amperes	345
2.5 amperes	70
3.0 amperes	35
4.0 amperes	10
Non-magnetic (tails)	10
Mechanical loss	30
	500

## EFFICIENCY EASILY CALCULABLE

The mechanical losses can be accounted for because of the difficulty in collecting all the magnetic products, as some did not fall in the hoppers, also because of some dusting and trouble experienced with the feed box not working properly. The recoveries figured on the heads minus the tails would be representative of the efficiency, as no trouble was found in collecting the non-magnetic portion.

TABLE II ANALYSIS OF NON-MAGNETIC TAILS

Run	Mesh	Per Cent Sulphur	Per Cent Iron	Per Cent CaO	Per Cent MgO	Per Cent SiO <sub>2</sub>
I	+20	14.54	18.35	1.15	3.84	59.30
II	-20					
	+40	13.36	14.45	2.11	4.16	54.75
III	-40					
	+60	18.00	27.45	1.58	4.42	36.75
IV	-60					
	+100	18.85	28.25	1.79	5.18	31.30
V	-100	22.80		Not determined		
VI	Original	17.43	26.70	1.70	4.66	35.70
VII	Original	18.90	30.67	1.44	3.48	37.80
VIII	+20	18.43	28.55	1.89	4.30	34.90
IX	-100	19.50		Not determined		

## RESULT OF ANALYSIS

The analysis was not made on tails of Runs V and IX, because this represented runs made on —100-mesh material; and referring to Table I we see that there was no practical concentration ratio, since at 3 and 4 amperes only 4.67 per cent and 2 per cent respectively remained in the non-magnetic tails. Referring to Table II, it would appear that Run I on 20-mesh material and Run II on —20+40-mesh material gave the best tails, cleaner in sulphur and iron than on the other runs.

However, the analysis on these runs cannot be compared with the others, since the tails were produced by employing as high as 5 amperes on Run I with 10 per cent non-magnetic substance and 4 amperes on Run II with 9.95 per cent non-magnetic material. Also an analysis made on the magnetic products of these two runs show that they are contaminated with more gangue material.

## THREE AMPERES BEST FOR COMPARISON

The basis of comparing the results obtained on the classified sized material and the original sample is best found at 3 amperes.

Referring to Table I and the analysis of products of the respective runs conducted at 3 amperes, the following table is derived for a basis of comparison.

TABLE III ANALYSIS OF NON-MAGNETIC TAILS

Run	Per Cent Non-Magnetic at 3 Amp.	Per Cent Sulphur in Tails at 3 Amp.	Per Cent Iron in Tails at 3 Amp.	Per Cent SiO <sub>2</sub> in Tails at 3 Amp.
I	20 mesh	22.25	20.49	Not determined
II	-20+40 mesh	37.50	23.51	Not determined
III	-40+60 mesh	31.68	18.00	27.45
IV	-60+100 mesh	31.00	18.85	28.25
VI	Original mesh	25.33	17.43	26.70
VII	Original mesh	29.86	18.90	30.67
VIII	+20+100 mesh	27.90	18.43	28.55

The above results clearly indicate that at 3 amperes the results obtained on the original material as received compare favorably with the screen-classified runs. Therefore, no classification would be advantageous in treating this material on the Wetherill machine. As was previously stated in this paper, 3 amperes was found best to employ on the discarded ore also.

## RECOVERY RESULTS TABULATED

The following table will show in detail the results retabulated on runs made on the finished product material as received, with the percentage of recovery figured on the sulphur and iron that remained in the tails.

Since the results obtained on unclassified material compared favorably with any of the classified material, only the recoveries on these runs will be considered.

TABLE IV RESULTS OBTAINED ON MATERIAL AS RECEIVED ON WETHERILL MACHINE AT 3 AMPERES

		S	Fe	CaO	MgO	SiO <sub>2</sub>	Per Cent Recovery S	Per Cent Recovery Fe
Run VI...	Heads	27.51	48.10	0.43	1.74	12.40		
	Conc.	31.20	55.40	nil	0.83	4.30	83.96	86.00
	Tails	17.43	26.70	1.70	4.66	35.70	16.04	14.00
Run VII Duplicate	Heads	27.51	48.10	0.43	1.74	12.40		
	Conc.	31.85	55.80	nil	0.94	3.85	80.00	80.97
	Tails	18.90	30.67	1.44	3.48	37.80	20.00	19.03

## RUN VI

72.90 per cent of the total silica (SiO<sub>2</sub>) remained in the non-magnetic tails  
 100.00 per cent of the total lime (CaO) remained in the non-magnetic tails  
 61.90 per cent of the total magnesia (MgO) remained in the non-magnetic tails

## RUN VII (Duplicate, run same as VI)

90.60 per cent of the total silica (SiO<sub>2</sub>) remained in the non-magnetic tails  
 100.00 per cent of the total lime (CaO) remained in the non-magnetic tails  
 59.70 per cent of the total magnesia (MgO) remained in the non-magnetic tails

From the average of the above two runs and the foregoing data, the following can be drawn:

## CONCLUSIONS FOR FINISHED PRODUCT ORE—PART II

1. That from 80 to 84 per cent of the sulphur can be recovered, from 80 to 86 per cent of the iron can be recovered to form a high-grade concentrate.
2. That from 72 to 90 per cent of the total silica can be removed, 100 per cent of the lime and about 60 per cent of the magnesia.
3. It is apparent that the gangue that collects in the concentrate is either picked off mechanically, due to the —100-mesh material, or else is more magnetic than the pyrrhotite that remains in the non-magnetic tails.
4. The best working amperage would be between 3 and 5, depending upon the grade and fineness of concentrate; on this particular experimental type machine, 3 appeared the best to employ on the unclassified feed. The concentration ratio is approximately 10 to 7.5.

## GENERAL SUMMARY

1. The experiments and tests have proved that pyrrhotite ores of the grade received can be successfully treated by magnetic separation. Whether a company is justified in installing several machines depends upon the extent of the ore deposit and the demand for sulphide ore.
2. No classification of the ore is necessary, but it should be stage crushed enough to unlock the sulphide mineral from the gangue. On the ore treated stage crushing through a 10-mesh proved satisfactory.
3. The cost of treating a ton of material which would require no classification would be less than \$1, and would possibly approach a few cents, depending upon the number of machines in operation, since one tender and a helper can easily take care of ten machines when in operation. A commercial size machine would probably treat between 5 and 10 tons of material per day. The depreciation of a Wetherill type magnetic separator is very slight, and the cost to operate would be covered by the cost of power going to magnets (3 amperes by 110 volts) and the power for motor operating machine. The capacity of any magnetic separator depends upon so many variables that it is impossible to estimate the exact tonnage until a test run has been made on a commercial size machine.
4. The grade of concentrate produced from the discard ore is superior to the grade received as finished product ore, and is equal to the concentrate obtained after treating the finished product material.

In conclusion, the author wishes to express his ap-

preciation and gratitude to Dr. R. B. Moore, superintendent of the Rocky Mountain Station of the U. S. Bureau of Mines, and Dr. S. C. Lind, acting superintendent, for their valuable advice and instruction throughout the progress of the work.

## The Engineer as a Citizen

What promises to be one of the most important meetings ever held by the New York sections of engineering societies will convene in the auditorium of the United Engineering Societies Building, Wednesday, March 26. The meeting has been arranged under the auspices of the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the Society of Automotive Engineers. The Electrical, Civil and Chemical Engineers as well as the American Chemical and Electrochemical Societies and other related organizations have been invited to participate.

The subject for the symposium is "The Engineer as a Citizen." It will be discussed under five heads, viz.

The Civic Responsibility of the Engineer. Philip N. Moore, A. I. M. E.

The Relation of the Engineer to Legislation. Calvert Townley, A. I. E. E.

The Relation of the Engineer to Administration. Nelson P. Lewis, A. S. C. E.

The Relation of the Engineer to Public Opinion. Spencer Miller, A. S. M. E.

The Relation of the Engineer to Production and Distribution. Comfort A. Adams, A. I. E. E.

## National Association for the Protection of American Rights in Mexico

Representative groups of industrial concerns operating or having interests in Mexico have recently organized an association for concerted action to protect their own property and to promote friendly relations between the United States and Mexico. The function of the association will be to collect data regarding conditions in Mexico and be prepared at all times to furnish information to the Government of the United States and the American public. It will endeavor to keep constantly in touch with both Governments and assist wherever possible in removing causes of friction. It is particularly emphasized that the purpose of the association is not to bring our Government into conflict with Mexico but to promote stability in the latter country and confidence in our own. Thus far the association is composed of petroleum producers, bankers and security holders, mining and smelting companies, agricultural and other interests. Business organizations having interests in Mexico are invited to join the association. Mr. Frank L. Silsbee is secretary, and is located at Room 2800, 120 Broadway, New York City.

## Work of the United States Employment Service

During the eight weeks ended Feb. 22, the United States Employment Service received 1,090,124 applications from men and women for jobs. Of this number 930,029 were referred to opportunities and 679,513 were reported placed in employment. The difference between the number referred to jobs and the number reported placed is due in a large measure to the failure either of the employee or employer to send in their return cards. Unless these return cards are received, the Service has no record of whether the prospect has received employment or not.



## Observations on Flaky and Woody Steel

Discussion of the Causes of This Troublesome Defect in High-Grade Alloy Steels by the Eminent Italian Ironmaster—Methods Are Outlined by Which Flakes and Woody Structure Have Been Brought Under Complete Control in Ansaldo's Works

By DR. FEDERICO GIOLITTI

General Manager of Steel Works, Giov. Ansaldo & Co.

I WAS very much interested in the discussion of flaky and woody structure in steel which took such a prominent part of the recent meetings of the American Institute of Mining Engineers. In Italy we are much interested in such defects, especially at the Ansaldo works, where about two-thirds of the guns used by the Italian Army were made. Our output was expanded many times in the last four years, in the face of a great lack of old and skilled workmen, so that during the war we manufactured more than 10,000 guns, with complete mountings. The defects known as flakes and woody structure have been known to us for some time, and we have done much experimental work which has enabled us to eliminate them almost entirely. The practical result of this experimental work was that none of the gun forgings manufactured in our works have been rejected on account of woody or flaky structure.

Our experience agrees roughly with the last paragraph of the résumé published in *CHEMICAL & METALLURGICAL ENGINEERING* for March 1, 1919 (page 219), except that we believe they are not formed as cracks in the ingot. Therefore we would state these sentences: "Flakes originate in tender alloy steels as intercrystalline cracks, probably intensified by inclusions and segregations. They can consequently be controlled by careful steel furnace practice, casting, soaking, reheating, forging and heat treating."

### CHOICE OF RAW MATERIALS IMPORTANT

Ansaldo's gun forgings are of acid open-hearth steel exclusively, made from the highest grade pure puddled iron and a very pure electric furnace pig produced in our own furnaces at Aosta from Alpine magnetites. We insist that phosphorus and sulphur be held at an extreme minimum. Of even greater importance, however, we feel that free iron oxide (scale and rust) be kept at the lowest possible point in the raw materials charged in the furnace. This refers to scale on the surface of the metal (rusty turnings and borings are never used) and free oxide in the puddled iron itself. Thus a pure wrought iron will contain considerable iron silicate as intercrystalline streaks which is not detrimental, but an impure Lancashire iron containing free oxide may not be used.

Starting from this pure iron, extreme care is used to prevent superficial oxidation during melting by maintaining a reducing flame in the open-hearth furnace at all times. The slag covering is very thin, consisting only of silica combined with the fluxed impurities in the original iron; it is maintained so that test buttons show a clear glass, of a straw yellow color. We refine very hot; some 20 min. before pouring, shoveling into

the furnace sufficient ferrochrome to produce the required analysis. At this time the condition of the metal and slag should be such that very little chromium is lost—one sign of good metal is that a 0.60 per cent chromium bath should produce not less than a 0.57 per cent chromium ingot.

### HOT POURING PREFERRED IN EUROPE

Contrary to Dr. Howe's recommended practice, we pour very hot. Our forging ingots are all fluted octagons, and our observations show that flakes, when they occur, have no habitual location or direction. The hot steel is cooled to 600 deg. C. in the mold, then stripped and left in the air. The cold ingot is then reheated just before forging to 1200 deg. C. as a maximum and the forging continued to a dull red heat. The large dendritic crystals formed in hot-poured ingots require care and skill in forging, it is true, but when rightly done such steel produces superior results, and so it has become a saying in our plants that when the outer part of hot-poured ingots has a tendency to crack under forging it is a sign of a good heat, and no rejections will occur.

### CHROMIUM STEEL, PROPERLY MADE, WILL NOT DEVELOP FLAKES

What I wish to emphasize is that chromium steel, properly made of pure materials in this manner under reducing conditions and containing no oxide, will never develop flakes. When so made you can pour it into an ingot of any cross-section and forge it as you like—either fast or slow, with reheating or without, with great or slight reduction (always providing the work is done within the correct temperature limits and with usual skill)—and flakes will not appear. We have made a large number of complete experiments to prove this point, using many types of ingots, then forging and treating them in many different ways for making different sizes of gun forgings. I have in my office complete records of these experiments, which I hope to be able to publish later.

As an instance of our contention that, if the steel is properly made, flakes are not produced by mechanical work, I may cite the fact that in November, 1917, after the Austrian advance which cost us so many men and guns, we wished to produce gun tubes at a rate far beyond the capacity of our forging presses. We therefore took our good steel ingots, heated them to the correct temperature and rolled them in a blooming mill, reducing their diameter from about 1.050 m. to about 0.250 m. in this way, without reheating. I do not need to remark that this practice produces intermetallic changes about as different as can be imagined

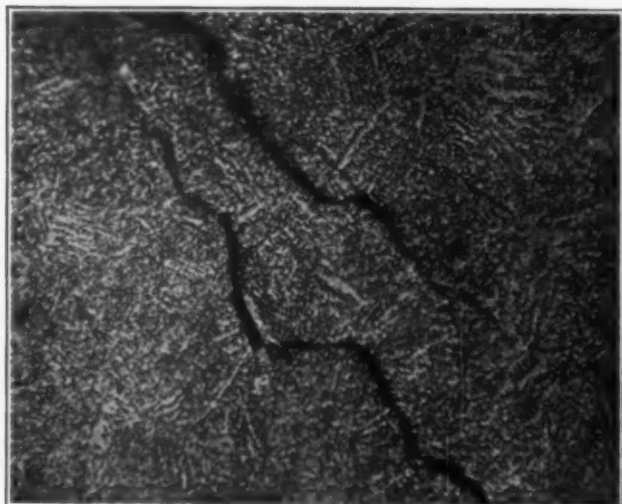


FIG. 1. FLAKES IN HEAT TREATED NICKEL-STEEL FORGING, AFTER RAWDON.  $\times 500$

from that by forging, yet not a single instance of woody or flaky structure resulted. After the pipe was cropped off, the balance of the piece was perfectly sound, as was established by numerous tests in all parts of the section. It was then bored and turned to dimension, and the resulting ordnance was satisfactory in all respects.

#### OXIDIZED INCLUSIONS RESPONSIBLE FOR FLAKES

On the other hand, a bath of metal properly made from correct raw materials will develop woody structure excessively if only a few kilograms of scale are thrown into the furnace even a long time before tapping. Microscopic examination of this defective metal seldom reveals an increased amount of inclusions, still we feel that this "oxidized metal" is flaky by virtue of its content of emulsified iron oxide, or some substance produced thereby which has diffused or broken up beyond the detection of a microscope. If rusty scrap or turnings are melted, the chances for rejection are increased enormously. Again, we found trouble as soon as the raw materials available were of inferior grade.

Such experiences as these convince us that flaky and woody structure, which two defects are near relatives, occur in steel containing highly oxidized inclusions. Usually these are beyond the power of the microscope to detect, yet sometimes larger non-metallic inclusions are found associated with flakes, as shown by Mr. Rawdon. The action of such larger segregations may be studied, and throw considerable light upon what I regard as the ultimate cause of flakes.

#### THEORY OF CAUSE OF FLAKING

It is necessary to explain why non-metallic inclusions are often surrounded by decarbonized zones—when this is explained the cause of flaking is also found. It certainly is not due to Ziegler's idea that ferrite, in being rejected from hypoeutectoid austenite, collects around the slag as a nucleus. Crystals usually form about points of like crystalline shape—ferrite grows upon ferrite, or upon isomorphous metallic substances. It seems to me that the presence of ferrite near a slag inclusion is due rather to a decarbonization caused in a manner somewhat like the following:

There exists in slowly cooled clean steel (normalized steel) a considerable quantity of gas in solution, such that a substantial equilibrium exists between the system  $\text{Fe}:\text{Fe}_3\text{C}:\text{CO}:\text{CO}_2$  according to the following equation



The gases  $\text{CO}$  and  $\text{CO}_2$  are occluded or dissolved in the metal (among other gases as well) in such a manner that no cavities are found, even ultra-microscopic. A similar equilibrium condition of an oxidizing slag may readily change with changing temperature in such a way that an excess of  $\text{CO}_2$  is transferred into the metal, unbalancing the equation given above and shifting it to the left, actually producing a zone of decarbonized iron in that vicinity, somewhat supersaturated with  $\text{CO}$  gas as well.

In this manner appears a spot of ferrite about an oxidized nucleus. On working, it flattens out into a thin sheet, perfectly continuous with the metal behind it and only separated at perhaps a minute point in the very center. But the flake is not in the real sense an internal crack—the crack with the characteristic bright flaky appearance does not exist until the piece is strained beyond the elastic limit of the surrounding unaffected metal. When this stronger metal stretches it throws a concentrated stress on the weaker ferrite spots, which forthwith fracture.

#### DISCUSSION OF THEORY

The following simple experiment is cited to sustain my theory of flake-formation. Take a piece of steel in which decarbonized zones surround a slag inclusion, and heat it to 1000 deg. C. in an atmosphere of  $\text{CO}$  for some 24 hours. On re-examination, the inclusion is no longer surrounded by ferrite. Again heat the sample, but this time in  $\text{CO}_2$ , and the ferrite envelopes reappear. In the first case the excess  $\text{CO}$  in the surrounding atmosphere overwhelms the  $\text{CO}_2$  from the inclusion, and the region is carburized; in the second case the preponderance of  $\text{CO}_2$  in the slag inclusion is re-established and decarburization ensues.

All these matters have been discussed by me completely in different papers published in 1914 in "Zeitschrift für Metallographie," and in 1916-17 in "Metallurgia Italiana."

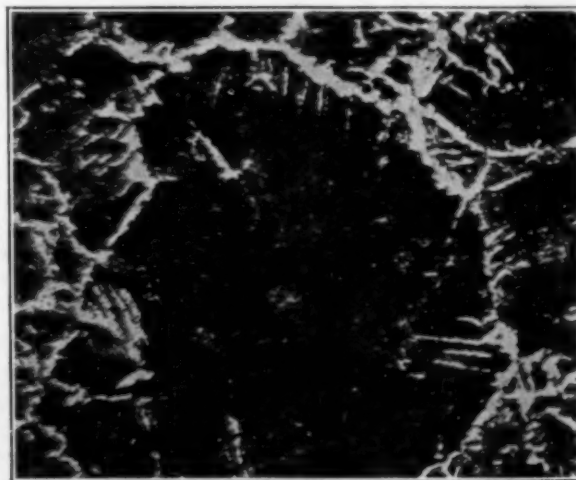


FIG. 2. FERRITE SEGREGATION IN HOLOCRYSTALLINE METAL, AFTER CLAYTON



Mr. Rawdon's sample (Fig. 1) is apparently of quenched metal, and the decarbonization along the flake (which does not need to be very deep-seated) is not in evidence. Should this specimen be annealed, it is probable the crack would then exhibit ferrite borders. Messrs. Clayton, Foley and Laney, on the other hand, showed lantern views where the crack is bordered by ferrite in coarse-grained metal something like the diagonal ferrite streak in Fig. 2. However, as can be seen from the preceding discussion, I differ from Mr. Clayton and his associates in that I believe the ferrite is due to invisible oxidized inclusions; the flake follows essentially these inclusions rather than true ferrite grain envelopes or Widmanstätten bands.

The fact that flakes are not found so frequently in carbon steels would support my hypothesis, since it is a well-known fact that carbon steels (under the same conditions) retain but few non-metallic inclusions as compared with these alloy steels.

#### WOODY STRUCTURE CURED BY HEAT-TREATMENT

If my gas-theory be true, it should be possible to cure woody structure by heat-treatment, and this has indeed been done systematically in the Ansaldo works when the steel was not actually overloaded with highly oxidizing slag. Such defective material if heated to 1000 deg. C. in reducing atmosphere (largely to prevent surface oxidation) for perhaps 12 to 18 hours, will allow a complete equilibration of the gaseous atmosphere and a ferrite diffusion resulting in a more uniform carbon distribution. As a matter of fact a measure of highest quality in steel is the ease by which structure caused by forging or rolling may be obliterated by heat treatment. (It is easy to show that inclusions are much more important in their effect upon "inheritance" and the appearance of free ferrite than are the original dendrites. Thus a piece of polished heat-treated steel lightly etched with MCl will show the outlines of the original crystalline grains. Repolish and etch with picric acid, and photograph the younger crystals in exactly the same area. Superimpose these micrographs and the older crystalline outlines will appear to have little relation to the younger ones.) These questions are also covered in the papers already noted, and to a greater extent in a volume on "Heat Treatment of Low Carbon Steels," published last year in Italy and now in course of translation into French and English.

#### WOODY STRUCTURE REDUCED BY LIGHT REDUCTION

Again, woody structure, if not excessive, can be diminished by careful and light reduction at temperatures from 1200 deg. C. to 800 deg. C. The exact explanation of this fact is not clear, except perhaps that forging at low heat destroys Widmanstätten structure, and with it any ferrite cleavages.

My opinion is founded on a careful study of the effect of visible inclusions on the constitution of the surrounding metal, on the mechanical properties of the steel and on the appearance of the fractures. A long account of these observations has been published in the volume already quoted. It may be noted that flakes differing widely in size and extent are associated with visible inclusions of the same size—large inclusions, if non-oxidizing in nature, do not give rise to flakes, while very small inclusions can produce very large flakes if

they have a highly oxidizing power. This oxidizing nature is revealed by the large areas of ferrite occurring around the inclusions in the slowly cooled metal.

These interesting and important matters I hope to discuss more at length upon my return to Italy, when I will have our original records and observations available.

New York City.

## American Electrochemical Society, New York Meeting

THE program arranged for the American Electrochemical Society, which will convene in New York City April 3 to 5, gives promise of meeting fully the hopes and expectations of those who planned the symposium on "Released Information." Members of the society who have been engaged in important war work of a chemical and electrochemical nature are now permitted to write and talk about the processes on which they have been working. The sessions will be held in Rumford Hall, Chemists' Club.

The annual business meeting and election of officers will take place Thursday morning, April 3, and will be followed by a technical session for the discussion of papers. The afternoon will be devoted to the same purpose. In the evening there will be an illustrated lecture by Mr. W. S. Landis on the Oxidation of Ammonia to Nitric Acid.

Both morning and afternoon sessions on Friday, April 4, will be devoted to the symposium on "Released Information."

Tentative plans are under way for an all-day trip to the chemical and metallurgical plants at Perth Amboy on Saturday, April 5. With the close of the war social features will be in order again and Section Q will be revived at a smoker.

Following are some of the papers that will be presented:

- Oxidation of Ammonia, W. S. Landis.
- Notes on Electrostatic Precipitation, H. D. Braley.
- A Process for Electrically Refining Nickel, G. A. Guess.
- Principles of Inductive Heating With High Frequency Currents, E. F. Northrup.
- Uranium, Gustave Gin.
- Remarkable Pitting of Electroplating, O. P. Watts.
- Electroplating Iron From the Copper Solution, O. P. Watts.
- Nelson Electrolytic Chlorine Cell, C. F. Carrier.
- Electrolytic Silver and Gold Refining at Perth Amboy, G. G. Griswold.

#### SYMPOSIUM ON "RELEASED INFORMATION"

1. Edgewood Arsenal, W. H. Walker.
2. An Electrolytic Process for the Production of Sodium Permanganate From Ferromanganese, R. E. Wilson and W. G. Horsch.
3. Silicon Tetrachloride, O. Hutchins.
4. Silicon Tetrachloride and Titanium Tetrachloride Smokes, G. A. Richter.
5. Portable Electric Filter for Smoke and Bacteria, A. B. Lamb.
6. The Preparation of Fluorine, W. L. Argo, F. C. Mathers, B. Humiston and C. D. Anderson.
7. Lead Plating of Shell Interiors and Boosters, A. G. Reeve.
8. Electric Furnace Manufacture of Silicomanganese, B. G. Klugh.
9. Electric Furnaces Used in the Production of Essential War Materials, T. F. Baily.
10. Chemical War Secrets and Releasing Manufacturers' Reports, E. Gudeman.

## Fusibility of Coal Ash\*

The Interior Province Coals as Compared With West Virginia Coals — Relation of Fusibility Tests to Clinker Formation — Interpretation of Fusibility Tables — Tables of Data on Illinois, Indiana, Kentucky, Kansas, Missouri, Oklahoma, Arkansas and West Virginia Coals

By W. A. SELVIG, W. C. RATLIFF AND A. C. FIELDNER

THE interior coal province, which includes all of the bituminous coal fields near the Great Lakes, in the Mississippi Valley and in Texas, contains a vast amount of coal which is extensively mined and has been a very important factor in the development of the great manufacturing centers of this region.

While there is a large amount of analytical data available as to the composition of these coals, there has been no general survey of the fusibility of the ash from the various coal beds. The fusibility of coal ash is of special interest to the consumer of coal in connection with the formation of clinker due to the melting of the ash constituents of the coal when fired under boilers. The Bureau of Mines is therefore making fusibility tests on the well-known American coals, and this paper gives a summary of such tests on the coals of the interior province, together with a comparison of similar tests on the well-known coals of West Virginia. A previous paper<sup>1</sup> gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash fusibility tests, together with a summary of such tests on West Virginia coals.

### RELATION OF FUSIBILITY TESTS TO CLINKER FORMATION

It is well to bear in mind that fusibility tests as made in the laboratory are not directly comparable to the conditions existing when coal is burned in a furnace, as in a laboratory test the impurities remaining as ash are intimately mixed, while there is no such uniform distribution when the coal is burned. Fieldner, Hall and Feild<sup>2</sup> have shown that in a laboratory fusibility test various factors have a great influence on the results obtained.

The standard gas-furnace method as used for the tests takes into consideration the different factors influencing the results obtained, with special reference to the atmosphere surrounding the ash during the test. With this method the atmosphere in which the ash is heated is readily controlled by burning an excess of gas, under

which condition a reducing atmosphere is obtained by which the iron in the ash is reduced to the ferrous state, which gives the lowest temperature at which clinkering may result. This is of special importance in testing ash from coals of the interior province, as they contain a relatively large amount of iron in the form of pyrite. Consequently, higher softening temperatures may be expected in tests using oxidizing atmospheres by which the iron would be oxidized to ferric oxide, or in tests using strongly reducing atmospheres by which the iron would be largely reduced to the metallic state. In both of these conditions a more refractory and viscous slag is formed than would result if the atmosphere were such as to reduce the iron in the ash to the ferrous state, which gives the most fusible condition.

Analyses of clinkers from boiler furnaces indicated that the conditions were such as to form clinkers in which the iron is present principally in the ferrous state, consequently the values obtained in the laboratory tests are in this respect comparable to the actual fuel-bed conditions, and give the lowest temperatures at which the intimately mixed ash will soften with the formation of clinker.

### INTERPRETATION OF FUSIBILITY TABLES

The tables of fusibility of coal ash tests give the average values for all mines tested in each coal bed. Average values for each mine were computed from the individual samples, which in practically all cases are standard mine samples collected by representatives of the Bureau of Mines, the United States Geological Survey, or by the various State geological surveys, according to the methods used by the Bureau of Mines.<sup>3</sup> A small number of car samples which were considered representative of the output of the various mines are also included.

The number of mines sampled and the total number of samples represented for each bed are given, as it is evident that the greater the number of mines sampled the more representative are the average values for the coal beds. This should be kept in mind, as in some cases the values given for the beds represent only a few mines and are then not truly representative of the coal bed.

The point taken as the softening temperature is that at which the ash when molded into solid triangular pyramids  $\frac{3}{4}$  in. high and  $\frac{1}{4}$  in. wide at the side of the base, and mounted in a vertical position, has fused down to a spherical lump. Points at which the tips of the cones first fuse and at which the ash become very fluid are also taken and serve mainly as an indication of

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<sup>1</sup>Lord, N. W., and others, "Analyses of Coals in the United States, With Descriptions of Mine and Field Samples Collected Between July 1, 1904, and June 30, 1916"; Bull. 22, Bureau of Mines, 1913, 1200 pp. (In two parts). Fieldner, A. C., and others, "Analyses of Mine and Car Samples Collected in the Fiscal Years 1911 to 1913"; Bull. 85, Bureau of Mines, 1914, 444 pp. Fieldner, A. C., and others, "Analyses of Mine and Car Samples Collected in the Fiscal Years 1913 to 1915"; Bull. 123, Bureau of Mines, 1917, 456 pp. Parr, S. W., "Chemical Study of Illinois Coals"; Illinois State Geological Survey, Coal Mining Investigations; Bull. 3, 1916, 86 pp.

<sup>2</sup>Selvig, W. A., "Fusibility of Coal Ash From West Virginia Coals"; CHEMICAL & METALLURGICAL ENGINEERING, Vol. 19, No. 12, 1918, pp. 826-828. For a complete table giving results obtained for each mine tested, see: Selvig, W. A., "Fusibility of Coal Ash From West Virginia Coals"; Coal Age, Vol. 15, No. 1, 1919, pp. 12-16.

<sup>3</sup>Fieldner, A. C., Hall, A. E., and Feild, A. L., "The Fusibility of Coal Ash and the Determination of the Softening Temperature"; Bull. 129, Bureau of Mines, 1918, 146 pp.

<sup>4</sup>Holmes, J. A., "The Sampling of Coal in the Mine"; Technical Paper 1, Bureau of Mines, 1911, 15 pp.



the viscosity of the melting ash; however, these values are not tabulated in the following tables. The average per cent ash and sulphur, on the dry coal basis, is given as a basis of comparison of the different beds.

Table I gives the various beds of the interior province arranged alphabetically under the different States, with the number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent ash and per cent sulphur on the dry coal basis.

TABLE I. FUSIBILITY OF COAL ASH FROM THE INTERIOR PROVINCE COALS

Region, State, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Degrees F.	Ash in Dry Coal, Average per Cent.	Sulphur in Dry Coal, Average per Cent.
<b>Eastern Region:</b>					
<b>Illinois</b>					
No. 1 Bed	1	6	2110	11.74	4.86
No. 2 Bed	6	15	2010	9.97	3.58
No. 5 Bed	9	27	1990	10.84	3.28
No. 6 Bed	36	160	2160	10.27	2.30
No. 7 Bed	2	13	2050	10.62	2.69
<b>Indiana</b>					
No. 3 Bed	3	11	2090	10.61	4.34
No. 4 Bed	7	30	2390	8.17	1.62
No. 5 Bed	9	29	2130	10.23	3.54
No. 6 Bed	1	5	2040	9.91	2.65
Minshall Bed	1	1	2120	9.60	2.99
<b>Western Kentucky</b>					
No. 6 Bed	1	4	2130	8.81	2.97
No. 9 Bed	20	78	2030	10.53	3.67
No. 10 Bed	2	2	1990	11.99	4.18
No. 11 Bed	7	39	2030	9.57	4.06
No. 12 Bed	3	17	2150	10.20	2.30
<b>Western Region:</b>					
<b>Kansas</b>					
Bevier Bed	2	6	1980	14.83	4.71
Cherokee Bed	3	8	2110	9.42	3.18
Leavenworth Bed	1	3	2020	18.26	5.46
Weir-Pittsburgh Bed	3	7	2010	11.68	5.31
<b>Missouri</b>					
Bevier Bed	16	42	1960	13.47	4.90
Bowen Bed	1	3	1940	13.18	4.61
Cainsville Bed	1	3	1980	12.71	5.78
Cherokee Bed	1	3	2150	7.51	1.97
Jordan Bed	4	12	2010	12.74	4.42
Lexington Bed	14	39	2000	13.48	4.04
Lower Rich Hill Bed	3	8	1940	15.39	5.43
Lower Weir - Pgh. Bed	2	6	1940	10.78	4.45
Mulberry Bed	2	5	1990	14.58	3.18
Mulky Bed	4	9	1940	11.28	5.25
Rich Hill Bed	1	3	1970	15.47	6.12
Tobo Bed	8	23	2040	11.64	4.66
Waverly Bed	1	2	2020	17.43	8.29
<b>Oklahoma</b>					
Dawson Bed	3	3	1920	8.95	3.91
Henryetta Bed	2	2	1980	8.03	1.59
Lehigh Coal Bed	3	15	2150	11.46	4.17
Lower Hartshorne Bed	9	27	2020	6.03	1.43
McAlester Bed	6	28	2180	6.94	1.67
McCurran Bed	1	6	2110	6.92	0.84
Panama Bed	2	4	2160	6.81	1.46
Stigler Bed	5	5	2050	5.13	1.91
Upper Hartshorne Bed	3	7	2170	6.15	1.51
<b>Arkansas</b>					
Denning Bed	1	3	2200	7.38	2.45
Hartshorne Bed	5	9	2120	11.59	1.40
Paris Bed	1	3	2140	10.12	3.28
Shinn Basin Bed	1	1	2180	10.36	2.23
<b>Southwestern Region:</b>					
<b>Texas</b>					
Santo Tomas	2	2	2580	19.21	1.98

Coals from all the States included in the interior coal province with the exception of Michigan and Iowa are given, there being no available mine samples of coals from these two States when the tests were made.

In order to compare the values obtained for the coals of the interior province with some of the standard coals of the country, values for the coals from West Virginia are given in Table II. Among these coals are some of the highest grade and best known fuels of the country. The coal beds are arranged according to their geological succession, the uppermost beds being listed first. It will be noted that among the softening temperatures given for the beds of West Virginia are values preceded by a plus sign (+). This indicates that the true values are above those given. Ashes which did not fuse at 2830 deg. F., which was the highest temperature attained in the gas furnace method, were heated to 3010 deg. F. in a molybdenum-wire resistance furnace in an atmos-

phere of hydrogen; hydrogen being used in this type of furnace to prevent the oxidation of the resistance wire. Ashes softening above 2830 deg. F. have such a low iron oxide content that the nature of the atmosphere surrounding the ash cones during the test has little influence on the fusibility. In a large number of samples of ash from the West Virginia coals the ash remained unfused at 3010 deg. F. These values were marked plus 3010 (+3010) and used as such in figuring the average values for the mine from which the average values of the beds were computed.

#### DISCUSSION OF FUSIBILITY VALUES

In general the softening temperature of coal ash from the various coal fields of the United States ranges from 1900 to 3100 deg. F. For convenience in discussion, the

TABLE II. FUSIBILITY OF COAL ASH FROM WEST VIRGINIA COALS

Series, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Degrees F.	Ash in Dry Coal, Average per Cent.	Sulphur in Dry Coal, Average per Cent.
<b>Monongahela Series:</b>					
Sewickley (Mapleton) Bed	1	5	2080	9.61	3.99
Redstone Bed	2	9	2120	6.08	1.95
Pittsburgh Bed	15	63	2170	7.49	2.45
<b>Conemaugh Series:</b>					
Mahoning Bed	4	4	2160	5.62	1.89
<b>Allegheny Series:</b>					
Upper Freeport Bed	1	1	2190	6.17	1.97
Lower Freeport Bed	2	2	2090	9.84	3.14
Middle Kittanning Bed	1	1	2110	10.93	4.06
Lower Kittanning Bed	7	22	+2490	8.48	3.28
<b>Pottsville Series:</b>					
<b>KANAWHA GROUP</b>					
Coalburg (Buffalo Creek) Bed	2	7	+2990	8.94	0.80
Winifrede Bed	3	4	2950	7.83	0.78
Cedar Grove Bed (Thacker Bed)	10	24	+2540	5.96	1.21
No. 2 Gas (Campbell Creek, Island Creek, Upper War Eagle) Bed	6	27	+2680	5.60	0.97
Eagle (No. 1 Gas, Middle War Eagle) Bed	1	3	+2940	4.40	0.77
<b>NEW RIVER GROUP</b>					
Sewell (Davy) Bed	33	95	+2580	4.36	0.66
Welch (Tug River) Bed	1	5	2840	7.41	0.62
Beckley (War Creek) Bed	22	101	+2800	4.82	0.68
Fire Creek (Quinnimont) Bed	3	17	2440	6.26	0.81
<b>POCAHONTAS GROUP</b>					
Pocahontas No. 6 Bed	1	6	2380	2.88	0.70
Pocahontas No. 5 Bed	2	3	+2610	5.45	0.60
Pocahontas No. 4 Bed (Thin Vein Pocahontas)	7	23	+2570	6.27	0.63
Pocahontas No. 3 Bed (Thick Vein Pocahontas)	66	246	2460	4.81	0.60

order of fusibility of an ash may be expressed by subdividing this range of softening temperature into three groups as follows:

Class 1, refractory ashes, softening above 2600 deg. F.

Class 2, ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3, easily fusible ashes, softening below 2200 deg. F.

#### WEST VIRGINIA COALS

The West Virginia coals include representatives of all three classes of fusibility. On the basis of the average softening temperature of all mines sampled from each coal bed, it is found that with the single exception of the Lower Kittanning bed, all the beds of the Monongahela, Conemaugh and Allegheny series belong to Class 3. There are, of course, individual mines here and there, as, for example, in the Pittsburgh bed in Marion County, which come in the lower part of Class 2.

Almost all of the mines in the Pocahontas No. 3 bed in McDowell County and half of the mines in Mercer County belong to Class 2. The remainder are in the lower part of Class 1.

The ash of New River coal is largely in Class 1, the Sewell bed averaging over 2580 deg. F., as compared to 2460 deg. F. for the Pocahontas No. 3 bed of the Pocahontas coal. The other important bed of this field is the Beckley or War Creek, having a uniformly refractory ash averaging over 2800 deg. F.

In so far as tested the Kanawha coals comprising the Coalburg, Winifrede, Cedar Grove, No. 2 Gas and Eagle beds also show a very refractory ash. Very little if any clinkering should be experienced in using these coals.

#### INTERIOR PROVINCE COALS

The coals from the interior province present a fusibility survey of entirely different aspect from that of West Virginia coals. With the exception of the No. 4

bed in Indiana and the Santo Tomas bed in Texas all the average fusibility values of the different beds are found between 1900 and 2200 deg. F. Furthermore, the fusibility of ash from different samples taken in the same mine usually shows comparatively small variation, averaging only 140 deg. F. in the mines represented in the table.

The low softening temperature of the ash from these coals is probably due to the pyrite, gypsum and calcite that occur so generally as impurities in coals from the interior province. A few mines producing low sulphur coal in the No. 6 bed of Franklin County, Illinois, belong to Class 2 as regards fusibility of ash.

In general it might be said that individual mines producing lower sulphur coal than the average sulphur values given for the bed in which they occur also gave higher fusibility of ash values than that indicated in the table for the bed.

Fuels Chemical Laboratory,  
Pittsburgh Experiment Station,  
Bureau of Mines.

## Change in Method of Distribution of Bureau of Standards Standard Samples

THE Bureau of Standards reports that it is making strenuous efforts to renew its depleted stock of standard samples. The great increase in the demand for these samples from regular sources and extra calls from the inspection sections of the War and Navy Departments, together with the inability to get increased appropriations for this work, have made it very difficult to keep the supply adequate. The demands of the military branches of the Government have made it impossible to procure the material for the renewal of some of the samples and have made it difficult to procure the machinery for the preparation of the iron and steel samples. It may not be realized generally that the preparation of a Standard sample consumes about three-fourths of the time required for the entire work upon it.

The present method of distribution has been known for some time to be cumbersome. New ordering and shipping regulations have therefore been adopted and ordered published on two additional pages 5 and 6 of the Supplement to Circular No. 25, "Standard Samples—General Information." This new supplement will be ready for distribution about March 15, and can be obtained on request from the Bureau of Standards, Washington, D. C.

As adopted, these regulations provide for the ordering of standard samples by number and name from the list printed on the first page of the above-mentioned supplement just as at present. From this time forward all samples for points in the United States or its possessions will be shipped by parcel post, C.O.D. Those for points in Canada, Mexico and other foreign countries will be shipped by express, C.O.D. The regulations of the Department of Commerce require that the payments for these samples be in the hands of Government agents before delivery can be made. By using the parcel post exclusively the Bureau hopes to make it possible for customers to send in their orders and pay for them through their own post office when delivery

is made. It is hoped in this way to make prompter shipments and avoid the necessity for refunds when samples ordered are out of stock.

The 10 per cent quantity discount heretofore given on four or more samples ordered at one time has been discontinued.

The Bureau has on hand at present a fairly adequate stock of the following:

Sample Number	Name	Constituents Determined or Intended Use	Weight of sample in grams	Fee per sample with certificate
1	Argillaceous limestone	Complete analysis	100	\$1.00
2	Zinc ore D	Zinc	100	1.00
4b	Iron B	C, Si, Ti, P, S, Mn	150	2.00
5c	Iron C	C, Si, Ti, P, S, Mn, Cu	150	2.00
7	Iron E	C, Si, Ti, P, S, Mn, Cu, Cr, Ni, V	150	2.00
8b	Steel, bessemer, 0.1 C	C, Si, P, S, Mn	150	2.00
9b	Steel, bessemer, 0.2 C	C, Si, P, S, Mn	150	2.00
11b	Steel, B. O. H., 0.2 C	C, Si, P, S, Mn	150	2.00
12b	Steel, B. O. H., 0.4 C	C, Si, P, S, Mn	150	2.00
15a	Steel, B. O. H., 0.1 C	C, Si, P, S, Mn	150	2.00
16a	Steel, B. O. H., 1.0 C	C, Si, P, S, Mn	150	2.00
17	Sucrose	Calorimetric value and saccharimetric value	60	2.00
20a	Steel, A. O. H., 0.4 C	C, Si, P, S, Mn, Cu, Cr, V, Ni	150	2.00
21a	Steel, A. O. H., 0.6 C	C, Si, P, S, Mn, Cu, Cr, V, Ni	150	2.00
22a	Steel, bessemer, 0.6 C	C, Si, P, S, Mn	150	2.00
24	Steel, vanadium, 0.15 V	C, Si, P, S, Mn, V (Ni, Cr, Cu, Mo)	150	2.50
26	Crescent iron ore	Al, O <sub>2</sub> , CaO, MgO	100	1.50
27a	Sibley iron ore	SiO <sub>2</sub> , P, Fe	150	2.00
28	Norrie iron ore	Mn (low)	100	1.50
29	Magnetite iron ore (titiferous)	Full analysis	150	2.00
33	Steel, nickel	C, Si, P, S, Mn, Ni (Co, Cr, Cu, W, Mo)	150	2.50
34	Steel, A. O. H., 0.8 C	C, Si, P, S, Mn (Cu, Cr, Mo)	150	2.00
35	Steel, A. O. H., 1.0 C	C, Si, P, S, Mn (Cu, Cr)	150	2.00
37	Brass, sheet	Cu, Zn, Sn, Pb, Fe, Ni	150	3.00
38	Naphthalene	Calorimetric value	50	2.00
40	Sodium oxalate	Oxidimetric value	75	1.25
41	Dextrose	Reduction value	70	2.00
42	Tin	Melting point	350	2.00
43	Zinc	Melting point	350	2.00
44	Aluminium	Melting point	200	2.00
46	Cement (normal)	Testing sieves	160	.25
47	Cement (extra fine)	Testing sieves	160	.25

There are at present in course of preparation samples Nos. 6c iron D, 13b B. O. H. steel 0.6 carbon, 14b B. O. H. steel 0.8 C, 23a bessemer steel 0.8 C, 25a manganese ore, 30a chrome-vanadium steel, 31a chrome-tungsten steel, 32a chrome-nickel steel and 37a sheet brass.

Of these it is hoped to have Nos. 30a and 37a ready for distribution by April 1, 1919. Nos. 6c and 25a should be ready by June 1 and the others will follow as rapidly as facilities will permit.



## Decomposition of Metals—I

A Critical Review of Various Theories Which Have Been Advanced From Time to Time to Explain the So-Called "Disease of Metal"—Allotropy, Recrystallization, Corrosion, and Season-Cracking May Each Be Responsible for Some Types of Such Failures

By COLONEL A. I. KRYNITZKY<sup>1</sup>

CONSIDERABLE popular attention has been attracted lately to the decay or decomposition of metals, although this is not new to technical literature. Thus, Messrs. Moissan and Ditte discussed the question of the decomposition of thin aluminium wire in the pages of *Comptes Rendus de l'Académie des Sciences* in 1898 and 1899. A very interesting study of the same decomposition was made by Ducru about twenty years ago, when he proved that such decomposition or self-destruction is accompanied by but very little chemical reaction or oxidation. Ducru examined under the microscope the parts which were in various stages of disintegration, and in some he noticed a nest of fire cracks. These observations were published later by H. Le Chatelier<sup>2</sup>, who, as did Charpy and Heyn, also studied various stages of decomposition of soldiers' drinking flasks.

Ernst Cohen brought these questions to life again in 1910, basing his essay on the work of Dr. von Hasslinger<sup>3</sup>. The latter started his studies with an accidental discovery. He attempted to use a pump which had stood without use for two years, and he found that it could no longer maintain a vacuum. Upon careful examination he found that the tin (the pump was made of tinned iron, soldered) had cracked and had become crystallized in spots. Besides, the whole surface, previously bright, had a crystalline structure and a dull appearance. Hasslinger supposed at first that this was the so-called "gray modification" of tin, stable below 18 deg. C. This idea was disproved, however, by the fact that the temperature of the laboratory had never fallen below 19 or risen above 45 deg. C., as was noted by maximum and minimum thermometers.

### "DISEASE" COMMUNICATED

To his great surprise Hasslinger further made a successful attempt to communicate this "disease" from the decomposing tin to some with a clean surface. Such "infected" pieces of tin, when kept at different temperatures (6, 19 and 37 deg. C.), exhibited a similar progressive decomposition, the surface becoming dull and crystalline in appearance, spreading in a circle from the point of infection at the rate of from 3 to 5 mm. a day, the speed decreasing as the distance from the center. Along the edges of such decomposed spots tiny cracks could be seen, and even beyond these cracks the tin was crystallized. The same results were obtained with the infection of tinfoil containing about 25 per cent of lead. In this case the decomposition penetrated

the full thickness of the foil and the decomposed part fell to pieces when shaken. High temperature did not affect the condition of the tin until the melting point was reached. Decomposed tin became normal after being melted.

Hasslinger also found that the melting points of the decomposed and normal tin were different: 205 deg. C. for decomposed and 231 to 232 deg. C. for normal material taken not far from the damaged portion. It must be noted, however, that the pieces of decomposed tin could not be absolutely separated from the last traces of the normal metal.

### ALLOTROPIC MODIFICATIONS OF TIN

It would not be out of place to mention some of the facts known in regard to the allotropic modifications of tin. These were observed by Erdman as far back as 1851. He noticed that tin organ pipes became decomposed in spots without any apparent cause—the surface of the metal became rough, swollen and covered with projections. After a sufficient length of time small grains of metal fell out, so that there finally appeared a hole in the wall of the pipe. Fritzsche (Petrograd) described similar cases in 1869 and several others during the period 1870 to 1897. Ernst Cohen described a case where a large part of a billet of very pure white "Banca" tin had decomposed into a gray powder after it had been received in Moscow. The gray modification could easily be scraped off with the fingernail. The writer, together with Eng. Koroboff, observed similar cases with Banca tin in the Petrograd Time Fuse Works.

According to Farup, in the case of cast tin the decomposition may be prevented, or at least considerably delayed, by adding some antimony to the metal. He has shown that the alloying metals may be divided into three groups as follows:

1. Hg.
2. Zn, Cd, Cu, Ag.
3. Bi, Sb.

Mercury is practically inert in its effect. Metals of class 2 have a slight influence, increasing in degree from left to right as they are written. Metals of the third class retard the transformation considerably.

Authorities differ as to the cause of such decomposition. Some attribute it to low temperature; others to low temperature together with shaking or vibration, and some to the decomposition which follows more or less rapid cooling of melted tin. Cohen and Van Eijk found that at about 18 deg. C. white tin transforms into a modification known as gray tin. In other words, there exists at least two allotropic modifications of tin, viz., gray, which is amorphous and has a specific gravity

<sup>1</sup>Member of the Commission for Inspection of the Artillery Orders of the Russian Government and Chief Inspector of Time Fuses.

<sup>2</sup>*Revue de Metallurgie*, 1911, Vol. 5, p. 373: "Etude d'échantillons d'aluminium spontanément désagrégés, remis par M. Ducru."

<sup>3</sup>*Revue de Metallurgie*, 1910, No. 4.

of 5.8, stable below 18 deg. C., and white, which is crystalline, has a specific gravity of 7.2 and is stable at temperatures above 18 deg. C. The transformation was found to be reversible.

#### TRANSFORMATION REQUIRES SOME TIME

The phenomenon of the transformation of white tin into gray—the so-called tin “plague”—is very much like that transformation well known to chemists where brown sulphur reverts into the yellow modification when it is slowly cooled after melting. On account of a certain amount of internal friction the transformation from one crystalline form into another requires some time. Thus the yellow spots which appear on the surface of the brown sulphur grow very slowly. Likewise, when white tin is cooled below 18 deg. C. it does not become gray immediately, but tends to remain as the white modification in an unstable condition. This may be compared with the unstable condition of oversaturated solutions; crystallization (and transformation) ensues on the introduction of a small fragment of the solute (or on contact with a particle of the transformed material).

In addition to the change into amorphous gray tin at 18 deg. C., the tetragonal white crystalline modification stable at room temperature changes into a rhombic modification at 161 deg. C., as was proved by Degens<sup>4</sup>, although previous investigations had placed this point at 200 deg. C. Trechman also determined the specific gravity of the rhombic tin to be 6.5 at 15.8 deg. C., while for the tetragonal tin at 15 deg. C. it was 7.2. Rhombic tin is very brittle; this explains a common method of producing tin powder, which consists of dropping tin when heated to about 200 deg. C. from a certain height upon iron plates.

The diagram, Fig. 1, represents different stages of the condition of tin, and graphically represents the following facts: At 18 deg. C. gray tin becomes white (tetragonal); at 161 tetragonal tin becomes rhombic; and rhombic tin melts at 232 deg. C. This cycle is reversible, and the dotted lines *df* and *c* indicate unstable conditions at ordinary temperatures.

Ernst Cohen<sup>5</sup> has carefully studied the allotropy of tin as well as of other metals. He discovered that the infection may be inoculated in tinfoil by means of the decomposed powder in such a way that it will show its effect on several thicknesses of the foil laid one on top of another. Cohen originally thought that he was witnessing simply a transformation of the normal tin with tetragonal crystals to the rhombic modification first described by Trechman and Foullon, as noted just above. This idea was disproved, however, by Hasslinger's temperature test, which showed that when infected tin was kept at different temperatures (7, 19 and 37 deg. C.) it continued to decompose.

A piece of tinned iron was infected in one spot and

kept in a thermostat at 184 deg. C. After one-half hour, the decomposition was noticeably spreading further and continued even after twelve hours. The same result was obtained in a thermostat held at 161 deg. C., while uninfected tin did not show any change whatever under the same conditions. Similar tests proved that the progress of the infection was still noticeable at 230 deg. C. (very near the melting point, 232 deg.), so that such decomposition could not have been explained by the transformation of tetragonal tin into the amorphous gray modification.

#### RECRYSTALLIZATION OF COPPER AND TIN

A new theory had to be advanced, and the following facts were taken as a basis. First, it has been proved that metal becomes more susceptible to electrolytic action if it has been drawn or forged. Forged metal is evidently in an unstable condition as compared with metal not forged. This can be seen from the fact that

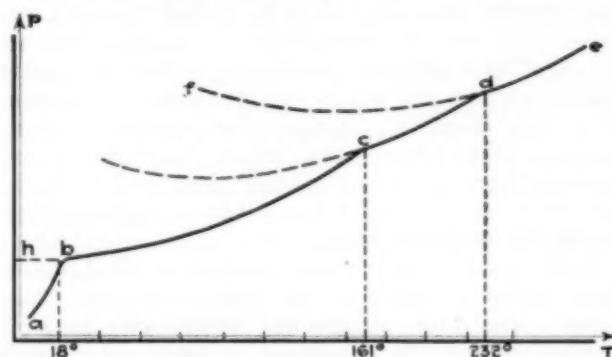


FIG. 1. ALLOTROPY OF TIN

in a galvanic battery composed of the forged and soft metals in a solution of a salt of the same metal, the forged metal becomes charged negatively and passes into solution. It is thought that the transformation of forge-hardened metal into a stable condition takes place even at ordinary temperatures, but at a very slow rate, so that it takes a long time before such transformation can be noticed. It proceeds more rapidly with rise in temperature, and also when the piece is brought in contact with the final (stable) modification.

A very good example of recrystallization was given by Baucke, who made the following experiment. He took two pieces of copper, hammered and annealed, respectively, and clamped their polished surfaces together. The combination was then heated to different temperatures successively, and it was found that at 105 deg. C. the hammered surface became considerably recrystallized. But when the surfaces were separated or insulated with an oil film there was practically no modification even after 48 hours at 180 deg. C.

The second basis for the new theory is derived from the ability of metals to change their crystalline structure. This means that the crystals can grow in size, which, as has long been known, takes place more rapidly with higher temperatures, although it appears probable that previous straining is a prerequisite to crystalline growth. Generally speaking, the following phenomena are included in the term “recrystallization”:

1. Change in the form of the crystals (polymorphous crystallization).
2. Growth of small crystals.

<sup>4</sup>*Zeitschrift für Anorganische Chemie*, 1909, Vol. 63, p. 207.  
<sup>5</sup>*Physical Chemical Studies of Tin*; *Zeit. Phys. Chem.* Vol. 30, p. 601; Vol. 33, p. 57; Vol. 35, p. 588; Vol. 48, p. 243; Vol. 50, p. 226; Vol. 63, p. 625; Vol. 68, p. 214. Also the following on allotropy are important: “On So-called Explosive Antimony,” *Ibid.*, Vol. 52, p. 129; “Amorphous Antimony and Bismuth,” Vol. 61, p. 588. “On the Metastability of Metals,” *Ibid.*, Vol. 71, p. 301; “Physical Chemical Studies of Lead,” *Ibid.*, Vol. 74, p. 202. “Atomic Volumes of Allotropic Modifications at Very Low Temperatures,” *Ibid.*, Vol. 71, p. 385. “Physical Chemical Studies of Bismuth,” *Ibid.*, Vol. 85, p. 419. “Physical Chemical Studies of Cadmium, Copper and Zinc,” *Ibid.*, Vol. 87, pp. 409, 419 and 426. although the very careful electrical resistivity measurements of G. K. Burgess and Kellberg do not indicate transformation of copper.



### 3. Change from an amorphous into a crystalline form.

According to Beilby's theory, it appears that when tin or any other metal is rolled or otherwise deformed beyond its elastic limit, its crystalline structure is destroyed in part.<sup>3</sup> It is possible, therefore, by rolling or forging tin plates to extreme thinness to get almost completely amorphous metal. Such plates can show recrystallization phenomena very plainly at temperatures below the melting point'. Heated in a thermostat at 150 deg. C., they become dull in appearance in a few minutes, and in about one-half hour at 110 deg. C. This surface under oblique light appears to be covered with scratches and under a magnifying glass (10:1) a net-



FIG. 2. RECRYSTALLIZED ANNULUS UNDER SPHERICAL DEPRESSION.  $\times 3.8$

work similar to that appearing on cast tin may be seen. This difference exists, however, that whereas the cast surface is marked with grooves separating crystalline groups, recrystallization produces a projecting mesh composed of the edges of the newly formed crystals. A study of similar cases with other metals has shown that this is not a new entity forming in the metal, but simply the merging and growth of the fractured and partly destroyed crystals.

#### RECRYSTALLIZATION OF STEEL

A very interesting study of the recrystallization of steel was made by Charpy<sup>4</sup>. He produced a depression in a piece of steel by means of a steel ball as is done in a Brinell hardness machine, and then planed this piece until the bottom of the depression was reached. The sample now had a perfectly flat and smooth appearance, but after annealing, the etched surface as viewed under the microscope had developed noticeable traces of deformation, as may be seen in Fig. 2. The large crystals on the periphery form a circle of about 10 mm. diameter, which is that of the steel ball used. Apparently, a critical shear and deformation took place near the center of this ring, which explains the more pronounced recrystallization in this place. Fig. 3 shows a part of

the same circle, magnified 100 times. Crystals on the periphery are in the lower part of the picture, and the center of the circle is beyond the upper.

Stead in 1898 had shown that the grains of ferrite develop most rapidly in low carbon steel at temperatures from 650 to 750 deg. C. Charpy proved further that under the same conditions ferrite grains grow more rapidly when the piece had been cold drawn or forged. He took a piece of soft steel, cut it in two, and subjected one end to cold drawing. Then both pieces were annealed at 650 to 800 deg. C. After cooling, each piece was broken in the middle. The fracture showed that the cold-drawn piece had a much larger crystalline structure. When the drawing affected the surface layers only, then large crystals were seen only near the surface.

Microscopic study shows that the difference in structure of such pieces of steel is only in the size of the grains of ferrite. The relative dimensions of these grains may be quite large, and in fact under favorable conditions of temperature, composition and past history the crystals may grow indefinitely until the whole piece of metal becomes one crystal'. This phenomenon is pronounced in the case of low-carbon steel with a certain percentage of phosphorus. The linear dimensions of grains of rolled annealed steel are ten times as large as those in annealed unrolled steel, and the volume, therefore, may be as much as 1000 times as large in

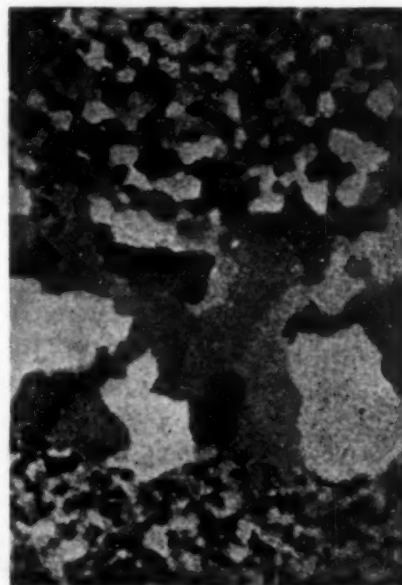


FIG. 3. RECRYSTALLIZATION UNDER SPHERICAL DEPRESSION.  $\times 100$

rolled annealed metal as compared to those in annealed unrolled steel.

Such development of crystals causes iron to be brittle. Thus, after the grains reach a certain size, the piece becomes so brittle that the work of breaking an impact specimen becomes almost zero. Charpy observed cases where steel rods, after being cold drawn, could stand considerable hammering without breaking, but after they were annealed at 650 deg. became so brittle that they broke into pieces when dropped on the floor. Every

<sup>3</sup>Beilby's theory of flow and resolidification in a vitreous-amorphous state postulates that layers of molecules many molecules in thickness have the mobility of the liquid state conferred upon them for a brief period; that it is the transient existence of this mobile phase which makes slip and movement among the lamellae possible and easy and that it is the sudden resolidification of these mobile layers into a non-crystalline or vitreous condition which arrests deformation under a given deforming stress. The original surfaces of any slip are now cemented together by the more rigid material and new surfaces of slip are only developed by higher stresses. The plasticity of the crystalline state is thus gradually used up and the aggregate as a whole becomes more and more rigid. When this has reached a certain stage, further increase in stress leads not to plastic flow, but to disruption.

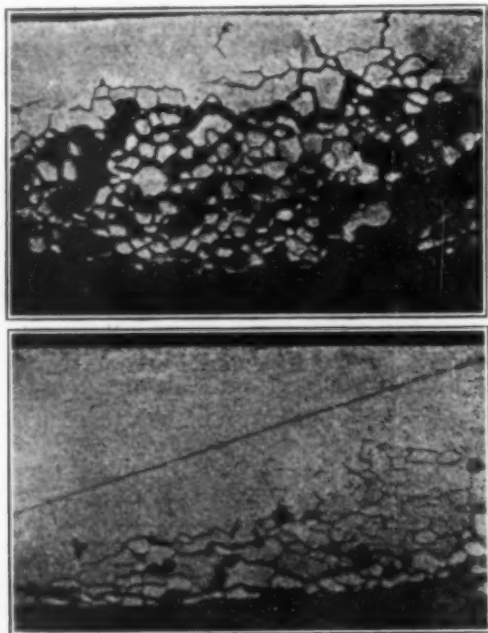
<sup>4</sup>Ewing and Rosenhain discovered that highly compressed lead recrystallized at all temperatures from ordinary up to the melting point.

<sup>5</sup>See also Sauveur's contribution to the Sixth Congress of the International Association for Testing Materials, New York, 1912, Vol. II, p. 6. Charpy, even as far back as 1893, investigated the process of recrystallization and formation of larger crystals in brass and steel under certain heat treatments.

<sup>6</sup>Zay Jeffries, "The Metallography of Tungsten," *Bulletin, American Institute of Mining Engineers*, No. 138, page 1037.

metallurgist can remember such facts from his practice."

Cohen concluded from these considerations that rolled tin must be in an unstable (metastable) condition, and that while the change to a stable condition takes place extremely slowly at ordinary temperatures, it progresses more rapidly at higher temperatures and especially when brought in contact with the stable form. Considering recrystallization as a growth of broken crystals, we can conclude that every cause that may help the growth of crystals at ordinary temperature will also produce Hasslinger's phenomenon of infection more quickly.



FIGS. 4 AND 5. DECOMPOSITION OF SURFACE OF ALUMINIUM FLASK (AT TOP) AND ANODE (AT BOTTOM).  $\times 50$

Infection may follow a purely mechanical action: If finely polished tin is hammered obliquely at one place, this spot becomes dull and can "infect" the other tin.

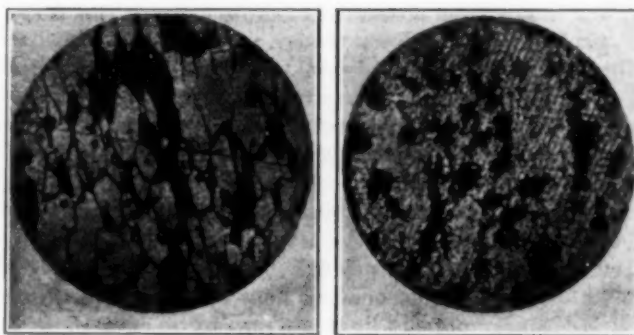
#### DISEASES OF ALUMINIUM

The diseases of aluminium described by Ducru were studied further by Le Chatelier. He used microphotography in his work with remarkable success, as can be seen from the accompanying photographs.

Fig. 4, magnified 50 times, shows a section through the bottom of a flask which failed after a short service. The gray-black powder on the surface of this metallic utensil consists, as is plainly shown, of small grains of metal.

Fig. 5, under the same magnification, shows a similar case, except that decomposition is less pronounced. This sample was used as an anode in a solution of sodium chloride. A current of a few milliamperes was applied for a few seconds. The polishing of these samples could be done only after the grains were fixed with melted rosin, which is the dark material separating the white metallic grains. The whole structure has traces of a cellular mesh. One can also notice cracks which are beginning to isolate separate grains of metal.

<sup>10</sup>See Howe, "The Metallography of Steel and Cast Iron," p. 359.



FIGS. 6 AND 7. SURFACE OF ALUMINIUM ANODE AFTER ELECTROLYSIS.  $\times 200$

Fig. 6, magnified 200 diameters, shows the same sample electrolyzed for several minutes with a current of 10 milliamperes per square centimeter. Such longer treatment develops the cellular mesh over the whole surface more clearly. The black polygonal depressions indicate places where the grains were torn away. That the metal did not dissolve at these points could be noted from the condition of the electrolyte, which contained many bright metallic specks.

Fig. 7 shows the surface condition of aluminium when treated in the same way, but which has not decomposed. One can see irregular black spots where the metal was corroded by the chemical reaction, but no crystalline structure of missing crystals is evident.

According to Le Chatelier, the decomposition of aluminium may be produced by mild chemical or mechanical action, such as may take place in a utensil over a flame or when containing hot liquids.

Le Chatelier attempted to show the effect of metallic impurities on such decomposition by the following experiments: Aluminium alloys containing 1 per cent of copper, sodium or calcium, respectively, were quickly heated almost to the melting point, and later annealed a long time at 100, 218 and 300 deg. C. At 200 deg. the alloy containing calcium showed something like a mesh-work, but hardly plainly enough to allow any conclusions. With heavily forged aluminium, decomposition may take place by itself, but when heated to 450

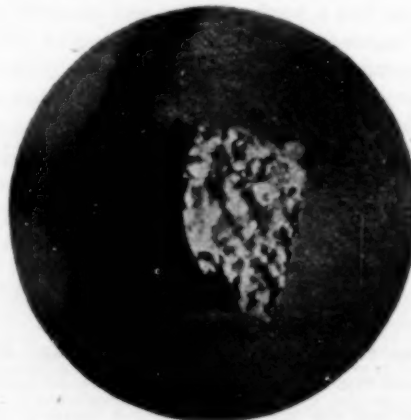


FIG. 8. FRACTURE OF CRYSTALLIZED BRASS ROD.  $\times 1.4$

deg. C. these defects disappear. On the other hand, contact with lime water aids decomposition.

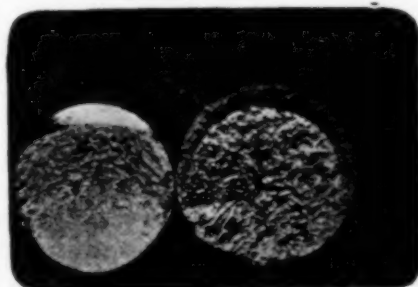
Fig. 8 shows a photograph of the break in a piece of brass rod 1½-in. in diameter, which had been rolled and then annealed. Nothing unusual was observed by the



author about this rod until, after some months' storage, it was dropped, when it broke into pieces. The illustration shows its coarse-crystalline structure—recrystallization.

In 1909 the writer became interested in the experiments with aluminium bronze described by Carpenter and Edwards in the eighth report of the Alloys Research Committee, 1907, and produced several interesting samples in the shape of rods, cast in sand or chill molds, and afterward rolled, annealed and drawn to the required size. The bronze used consisted of 91 per cent copper and 9 per cent aluminium, and the working was all done in the cold. These rods were stored in a room where the temperature varied from about 5 to 20 deg. C. A year later a number of cracks appeared on the surface of some of these rods. Fig. 9 shows a break in a rod which did not have any surface cracks: the break has a uniform velvety appearance. The narrow white stripe shown in the photograph is due to the fact that here the fracture of the rod was considerably higher. Fig. 10 shows a similar break in a rod containing cracks, in a good portion of it between two neighboring cracks. This illustration shows a much more ragged fracture with two distinct zones, a narrow yellow crescent outside encircling the gray-white inside. Fig. 11 shows a fracture from the same faulty rod, but taken through the good portion of it where it exhibited no cracks. In appearance this fracture lies between those of Figs. 9 and 10, the yellow outer circle not being evident. The two black stripes shown on the left and right edges are the traces of the saw cut.

Many other similar cases were investigated with the same result: a large number of "season" cracks being usually accompanied by the more crystalline break, while the yellow circle sometimes covered almost the whole cross-section. Unfortunately the microphotographs



FIGS. 9 AND 10. ON LEFT—FRACTURE OF NORMAL ALUMINIUM BRONZE. ON RIGHT—OF ALUMINIUM BRONZE CONTAINING SEASON CRACKS.  $\times 2$

were not distinctive enough to draw many lines of demarcation. Also to the writer's regret it was not determined how cracks were passing—between crystals or across them. According to W. H. Bassett<sup>11</sup> with wrought brasses in the  $\alpha$  phase, the cracks always pass between the crystals. H. S. Rawdon<sup>12</sup> in his microscopic examination of the cracks pass through the beta. When the alloy is entirely in the  $\beta$  phase, the cracks generally pass across the crystals. H. S. Rawdon<sup>12</sup> in his microscope examination of samples of brass which has season-cracked

in some mercury solution found that cracks were intercrystalline; in cartridge brass in which there are only the  $\alpha$  crystals, the cracks are truly intercrystalline. In manganese bronze (60-40 brass) the cracks follow, in general, the boundary surfaces between the  $\alpha$  and  $\beta$  constituents.

It has been proved beyond any doubt that cold forging and drawing may actually facilitate the decomposition of metals. These facts are characterized by Cohen as "diseases due to cold forging of metals" ("Forcierkrankheit").

#### HEYN'S LIMITING CONDITIONS OF EQUILIBRIUM

In view of the foregoing discussion, it may be stated that decomposition of cold drawn and forged metal is now firmly recognized, but we have yet no satisfactory explanation as to its true cause. Many theories have been offered, and it would be difficult to criticise them,

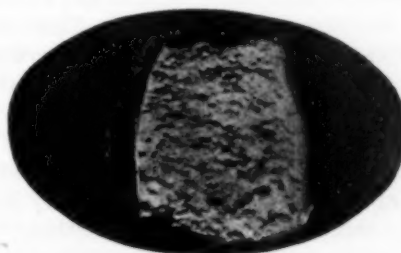


FIG. 11. FRACTURE OF CRYSTALLIZED ALUMINIUM BRONZE.  $\times 2$

since, as Heyn said, "Their usefulness may be measured only by their success in opening new scientific horizons and giving fresh impetus for further studies and experiments."

Behrens and Cohen have advanced their theory of recrystallization of metals as described above. The bearing of Beilby's amorphous theory has also been indicated.<sup>13</sup> A most noteworthy explanation of the observed facts, in the writer's opinion, has been offered by Heyn, who suggests that metal during drawing stores up energy, so that overstrained metal has a natural tendency to approach a stable condition which possesses the minimum amount of energy. He therefore controverts Beilby's idea that there should be considered two forms in forged material, namely, crystalline and amorphous, saying that during working the grains get longer and thinner, thus increasing the surface energy of each crystal. Consequently the total energy in the piece also increases, and the action produces an unstable condition in the metal.

Going further, one may assume that along certain surfaces of slip cold work, increased to such an extent that there remain, in consequence of the high degree of splitting up the grains, films consisting almost only of moles or groups of moles, this might be assumed to be a transition of the metal from the crystallized phase into another amorphous phase. According to Heyn, however, it would be more natural to assume that forging develops a thin layer of the same crystalline phase, in which, owing to the cold working, the potential energy is locally raised to a very high figure. In Heyn's opinion, we have to differentiate between "phase equilibria" and the equilibria which are dependent upon

<sup>11</sup>"The Causes and Prevention of Corrosion Cracking," by W. H. Bassett, *Proceedings, American Society for Testing Materials*, 1918, Vol. XVIII, part II, pp. 153-162. "The Use of Mercury Solutions for Predicting Season Cracking on the Brass," by Henry S. Rawdon, *Ibid.*, pp. 189-200.

<sup>12</sup>*Proceedings, International Society for Testing Materials*, 6th Congress, New York, 1912, First Section, II, page 43.

the surface energy. If grains in the metal are split up or stretched by cold work the phase equilibrium remains unchanged, but the equilibrium of the size of grains and of the shape of grains is disturbed owing to the increase of the surface energy. A stable condition is attained only when each phase will have uniform crystalline grains each of such shape and form that the surface energy will be a minimum at all limiting surfaces.

From this standpoint all our metals and technical alloys are in a more or less unstable condition, depending on the size of the crystals and their elongation. The further away they are from the stable conditions, evidently, the more the tendency to approach it. Ordinarily such reversion can take place but partially, as the regroupings of the small grains with high surface energy into large equi-axed crystals of small specific energy become difficult on account of the friction offered molecular movement in the solid. This friction, of course, varies with the pressure and temperature. Consequently, for a given pressure and temperature, there exists an initial degree of equilibrium, which is materially constant.

Heyn defined this as a "limiting state," comparing it with that of a body on an inclined plane, down which it is just prevented from sliding by friction. Therefore, if any factor tends to increase the deformation of the forged metal, then, according to Heyn, this factor also increases the rapidity with which the metal approaches such "limiting state" for the given temperature, pressure and initial degree of stability.

Heyn's theory is a theory of internal strains. He, together with Bauer, even developed a method to determine the amount of such stresses, which may reach a considerable value, exceeding sometimes the ultimate strength, for instance, in forged pieces of nickel-steel, brass or delta metal. These strains disappear after proper annealing at given temperatures. According to the latest researches, they disappear even at comparatively low temperatures.

At the same time, nevertheless, all factors such as additional stresses due to mechanical forces, to irregular heating and cooling, to washing, cleaning, chemical treatment or vibrations tend to increase the decomposition.

According to P. D. Merica and R. W. Woodward,<sup>28</sup> "The welding or burning-in of castings or other articles will also generally produce initial stress in the cooled piece, the welded portion being in tension parallel to the surface and perpendicular to the weld. If a round bar of brass is suddenly cooled by quenching from a high temperature, the outer half of the cross-section will be left in longitudinal compression, the inner half in tension. Measurements have shown that in 1-in. round bars of naval brass and manganese bronze quenching from 450 deg. C. into water produces an average longitudinal, initial compressive stress over the outer half of the cross-section of 14,500 lb. per sq.in."

Investigating the cause of the frequent splitting of the thin steel pipes used in evaporating and precipitat-

ing potassium and sodium carbonates, Stromeyer<sup>29</sup> noticed that these cracks appeared only in places where the pipes were subjected to tensile forces. He then prepared specimens, each of two rings, of which the outer one was forced under pressure over the inner one so that the inner one was under compression, with the outer one under tension. These double rings were placed in a solution of sodium carbonate under the same conditions as obtained in the commercial apparatus, and he found that the outside ring cracked, while the inside remained intact. Unstressed rings also remained unchanged.

Heyn cites these interesting experiments conducted by Stromeyer, and points out that some particles in forged metal may be under unbalanced tension as compared with the tension of other particles. Similar strains exist within certain limits in metals subjected to cold shearing. It is interesting to note that somewhat similar stresses were described and explained by Professor D. Tchernoff in his report to the Imperial Russian Technical Society in 1884. He studied the stresses which appear after cold punching or shearing of steel plates and noted that they spread in waves, increasing the elastic limit of the material in the crests of the waves. This phenomenon is known as the "Lüders-Tchernoff lines." Some years later (1895) it was described also by Captain Hartmann. It must be noted, however, that Tchernoff's lines were first observed and described in 1860 by Lüders, who gave them a different explanation<sup>30</sup>.

### New Process for the Manufacture of Sulphonic Acids

The Department of Agriculture announces that the Color Laboratory of the Bureau of Chemistry, Department of Agriculture, has developed on a laboratory scale a new process for the manufacture of certain sulphonic acids. This process, as carried out in the laboratories, appears so promising that it is thought that some manufacturers of chemicals and dyestuffs in this country may be able to supply their demands for these and other valuable compounds by this process, provided the process can be reproduced upon a technical scale so as to obtain results commensurate with the laboratory investigations. The process refers particularly to the sulphonation in the vapor phase of benzene, naphthalene and other hydrocarbons.

With a view to helping the chemical industry of this country, the Department of Agriculture announces that it is ready to assist manufacturers who wish to produce these compounds. The expenses of the technical installation and of the labor and materials necessary will of necessity be borne by the firm, individual or corporation wishing to manufacture the products. The chemists of the Color Laboratory will assist with expert advice, etc. The Department reserves the right to publish all the data obtained from the technical experiments. This offer of assistance will not be held open by the Department for an indefinite period.

<sup>28</sup>Journal, Iron and Steel Institute, 1907, I, p. 200; 1907, III, p. 86; 1909, I, p. 404. *Proceedings*, Institute of Civil Engineers, 1886, Vol. 84, p. 144; 1888, Vol. 93, p. 89.

<sup>29</sup>"Initial Stress and Corrosion Cracking," by P. D. Merica and R. W. Woodward. *Proceedings*, American Society for Testing Materials, 1913, Volume XVIII, Part II, pp. 165-178.

<sup>30</sup>"Ueber die Aeusserung der Elasticität an Stahlartigen Eisenstäben und Stahlstäben, und über eine beim Biegen solcher Stäbe beobachtete Molecularbewegung," von W. Lüders, *Dingler's Polytechnisches Journal*, 1860, Heft 1, Tages 18-22.



## Temperature Uniformity in an Electric Furnace\*

A Method of Manufacturing Laboratory Electric Furnaces Producing a Uniform Temperature From End to End of Core—Three Independent Heaters in Addition to End Plugs—Alternate Layers of Insulating and Conducting Materials to Distribute Heat

By JOHN B. FERGUSON

THE problem of temperature uniformity in an electric furnace is intimately connected with almost all investigation carried on at high temperatures. For this reason it has generally been considered as a part of a larger problem and has been solved to the extent demanded by the requirements of the work at hand. In the present paper the writer wishes to discuss the conditions essential for a proper control of the temperature distribution, and the previous attempts that have been made to attain these conditions; and to describe in detail a type of horizontal furnace which he has found suitable for investigations requiring a uniform temperature over the range from 620 to 1190 deg.

### GENERAL DISCUSSION

The maintenance of a region of uniform temperature in an electric furnace requires that full compensation be made for the heat losses at all points within this region, and the ease with which such a compensation may be obtained is an inverse function of the magnitude of these heat losses. This is not, however, the only factor to be considered in determining the insulation required by any given furnace. If a uniform temperature is to be obtained this insulation must be thick enough to render negligible the effect of non-uniformity in the temperature of the furnace surroundings, and if, further, a constant uniform temperature is to be obtained the insulation must also be of such thickness that fluctuation in this external temperature with time will be without effect. In the former case alternate thin layers of a good conductor and a good insulator may be used to advantage to replace thick layers of a slightly poorer insulator, giving the same uniformity of heat losses but with much reduced lag effects.

The heat losses are never uniformly distributed in a furnace, and the heat supply must likewise be non-uniformly distributed. If the heat losses are of different magnitudes but all similarly dependent on the furnace temperature (an unusual case) a non-uniform heater could be constructed which would afford a compensation over a range of temperatures; but if these losses are not similarly dependent on the furnace temperature (the usual case) then such a non-uniform heater would provide a compensation at one temperature only. In this latter case, if a compensation is desired over a range of temperatures, the single non-uniform heater must be replaced by as great a number of independent heaters as there are independent heat losses.

The ordinary electric furnace in which a column of air is heated is the best known example of a region with non-uniform heat losses and is the type the writer

wishes particularly to consider. In such an air column, provided convection is eliminated, there will always be a short region having a fairly uniform temperature. The length of this uniform temperature region will be dependent upon the length of the furnace, and for some work a furnace sufficiently long to provide a suitable region of uniform temperature can be used without further attention to end conditions. But the usual problem confronting an investigator is to increase the length of this region without increasing the length of the furnace. The introduction of insulating plugs or baffle plates will cut down the end losses by conduction and radiation and will give a result similar to that obtained by lengthening the furnace. For this purpose a plug of good insulating material is much less efficient than a composite plug made up of good and poor conducting layers, the first of the former being on the inside of the plug next the region to be uniformly heated. Such a plug has two functions: (1) to reduce the end losses by insulating the region, (2) to distribute the heat losses and also the heat supply uniformly across the plug and thus take full advantage of the heating effect of the ends of the heater. This latter precaution is particularly important in furnaces of large diameter.

In many cases the region to be heated uniformly is such a large portion of the whole air column that even composite plugs are inadequate and in this case the simple uniform heater has to be discarded. A specially wound heater designed to give an increased heat supply at the furnace ends will increase the length of the region of uniform temperature and will yield a maximum length at one particular temperature, since with the materials at our disposal the average furnace must be so constructed that the relation of the heat losses to the furnace temperature varies. The use of a furnace of this type is naturally limited, since it is difficult to design a heater that will give the maximum length to the region of uniformity at a predetermined temperature. Special and separate end heaters independent of the main heater offer the most practicable solution, as they enable one to obtain equally good compensation over a range of temperatures.

In designing such a furnace the thickness of the layers of good and poor conducting materials employed will depend on the conditions under which the furnace is to be used and the degree of uniformity required. In general a horizontal furnace gives a better temperature distribution than a vertical furnace of the same dimensions. Two reasons may be given for this: (1) The convection currents in the air column of the vertical furnace are more active and may be considerable if the furnace is not gas tight; and (2) the temperature

\*Republished from *Physical Review*, Vol. XII, No. 1.

distribution over the outside of the vertical furnace is much less uniform than in the case of the horizontal furnace. The horizontal furnace has therefore been much more frequently used and was the type employed by the writer.

Almost all investigators in the field of high temperature have been obliged to consider the problem of temperature uniformity. In this paper it is obviously impossible to present all the results that have been obtained and the writer has chosen to present only the work which best illustrates the points he desires to emphasize. In fairness to those quoted the reader should remember that most of them were interested in the development of a furnace suitable for their particular need and in that alone.

#### PREVIOUS WORK

Among the earliest investigators to touch upon this problem were Holborn and Day,<sup>1</sup> who in 1899 experimented with both uniform and non-uniform heating coils. They found that the latter gave the better temperature distribution but with an optimum uniformity for a short range of temperature.

A somewhat more complicated furnace was used by Waidner and Burgess.<sup>2</sup> It consisted of two concentric furnaces, the outer having a long heater with crowded end windings while the inner was shorter and uniformly wound. In such an arrangement, the end and center heat supplies are only partially independent of each other and so the compensation is still a function of the temperature, although not as dependent on it as in the case of the single non-uniform coil. These conclusions are entirely borne out by their results.

In 1908 Day and Clement,<sup>3</sup> confronted with the same problem that had confronted Holborn and Day in 1899, were able with a new furnace to obtain along their gas-thermometer bulb a temperature distribution which did not vary over 1 deg. up to 1200 deg. This they did by means of independent auxiliary end heaters which, like the main heating coil, were wound (one in each end) on the inside of the furnace tube and were separated from the main coil by a layer of refractory magnesite cement.

Two slightly different types of furnace were used by Day and Sosman<sup>4</sup> in continuing the work of Day and Clement in 1910. Both had baffle plates in the unused portions of the air column which cut down the end losses by radiation. These end radiation losses, which seem to have been overlooked by all the previous investigators, were found to be of considerable magnitude. The furnaces differed only in the form of the heaters. In the first, the main heater was slightly crowded at the ends and inside wound, while the end coils were similar to those used by Day and Clement. In the second, the heating coil was divided into three units subject to independent control, and was wound on the outside of a thick tube of good conducting material. This second furnace yielded the better temperature distribution but could not be used at the highest temperatures.

The three-heater principle first used by Day and

Clement was also employed by Gray,<sup>5</sup> who desired the greatest uniformity attainable. Instead of separating his good conducting baffles by air as Day and Sosman had previously done, he used a layer of a good insulating material. This type of plug, though very similar in principle to the plug used by Day and Sosman, is probably better, since it is a better longitudinal insulator. The fact that metal baffle plates separated by thin layers of air form, in effect, a composite plug conducting transversely and insulating longitudinally apparently did not occur to Gray, who independently later developed the idea. His first furnace, in addition to such plugs, contained thick-walled iron tubes and was heated by three independent heaters; the main heater was of basket weave; the other two were situated in the outer portion of the plugs. Evidence of severe local heatings led him to rebuild the furnace with two concentric heaters of basket weave and larger end coils which now were placed outside of the plugs and covered a considerable portion of the furnace ends.

Gray did not fully appreciate the value of the independent heater idea<sup>6</sup> and attributed his success mainly to other causes. His description implies that such plugs as are described above will enable one to use a furnace with crowded windings over a range of temperature. This is generally true, for if the windings

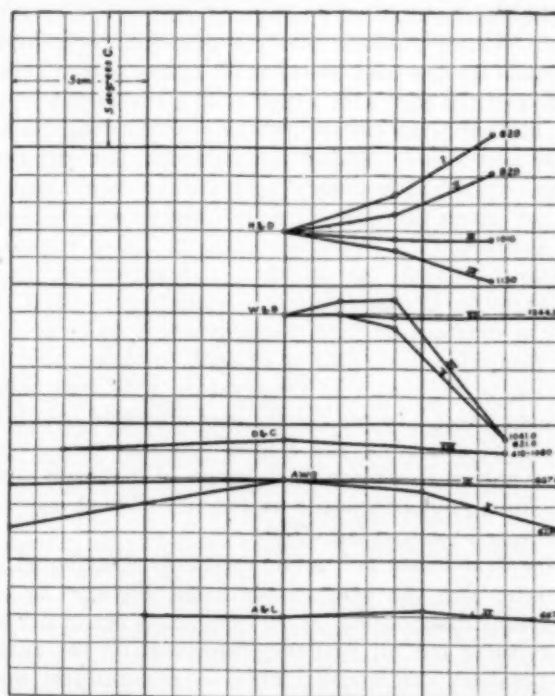


FIG. 1

Curves I, II, III and IV: Uniformity attained in a furnace with crowded ends by Holborn and Day. Curves I and II indicate an over-compensation, and Curve IV indicates an under-compensation of the end heat losses. Curves V, VI and VII: Distribution obtained by Waidner and Burgess at different temperatures. Curve VIII: Results of Day and Clement obtained by means of a furnace with three independent heaters over a range of temperature. Curves IX and X: Results obtained by A. W. Gray. IX shows the temperature distribution with composite plugs and end coils and X with plugs alone. Curve XI: Results of Allen and Lombard.

<sup>1</sup>Bull. Bur. Standards, 10, 451, 1914.

<sup>2</sup>In his discussion of this subject, Gray apparently overlooked the various investigations in connection with high-temperature thermometry, for he says: "Previous experimenters have tried to secure uniformity of temperature in an electrically heated air column by using the central portion of a long tube and by crowding the windings near the ends or other places where the heat was lost most rapidly," whereas several of the investigators referred to had already used independent end heaters.

<sup>1</sup>Holborn and Day, *Ann. d. Phys.*, LXVIII, 815, 1899; *Am. J. Sci.*, (4), 8, 165, 1899.

<sup>2</sup>Bull. Bur. Standards, 3, 165, 1907.

<sup>3</sup>Day and Clement, *Am. J. Sci.*, (4), XXVI, 405, 1908.

<sup>4</sup>Day and Sosman, *Am. J. Sci.*, (4), XXIX, 93, 1910.



are crowded so as only partially to compensate over the range of temperatures at which the investigator wishes to work the additional compensation may be obtained from the end heaters and a good temperature distribution will result. It will not be a convenient furnace to work with, however, as will be discussed later. But if the furnace is so wound that at any temperature within the range of temperatures considered a perfect compensation is made without the end coils, then at higher temperatures there will be under-compensation and at lower temperatures over-

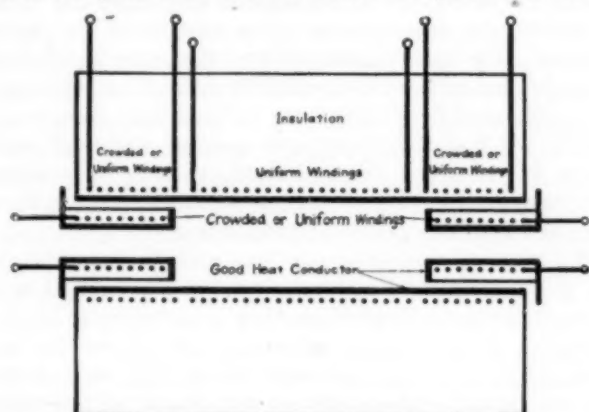


FIG. 2. IDEAL SECTION OF CYLINDRICAL FURNACE WITH INDEPENDENT END HEATERS AND PLUGS

compensation by the crowded ends. Obviously, if there is over-compensation a plug by means of which the supply of heat at the ends can only be kept constant or increased offers no possibility of a solution. The basket weave would seem to have been a detriment rather than an aid, since a single main heater of that type was insufficient and two were necessary to avoid severe local heatings.

The form of the plugs is not as important as would appear from Gray's experiments. The main requisite is the separation of the heaters from the region to be heated by sufficient material to smooth out any local

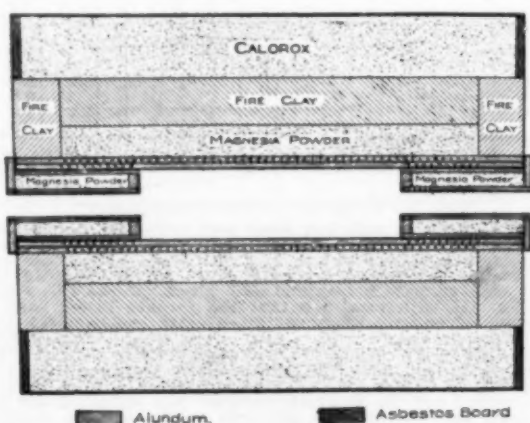


FIG. 3. CROSS-SECTION OF CYLINDRICAL FURNACE WITH END HEATERS AND PLUGS, SHOWING DETAILS OF CONSTRUCTION

heating effects. Just how much latitude there may be in the designing of plugs, end coils, etc., may be gathered from the work of Allen and Lombard<sup>7</sup> and also that of the writer. The furnace of Allen and Lombard had flat end coils that did not cover the plugs,

and also solid asbestos caps, while the main heater was a single coil wound on a helically grooved alundum tube with walls 0.5 mm. thick. With this furnace a uniformity equal to that obtained by Gray at approximately the same temperature was obtained. In Fig. 1 curves representing some of the work referred to are given.

#### EXPERIMENTS

The actual design of any furnace is dependent on the purposes for which it is intended and the materials and facilities the experimenter has at hand. It is therefore doubtful whether any special design will have a very general application.

Nevertheless a description of a furnace may furnish the prospective designer with much useful information, and for this reason a description of a 45-cm. furnace capable of uniformly heating a region 6 cm. in diameter and 10 to 12 cm. long at temperatures ranging from 1000 to 1200 deg., and maintaining this uniform temperature constant for long periods of time, will be given. In the development of this furnace a number of types were tested out, and of these a few proved satisfactory. The final changes were made with the intention of

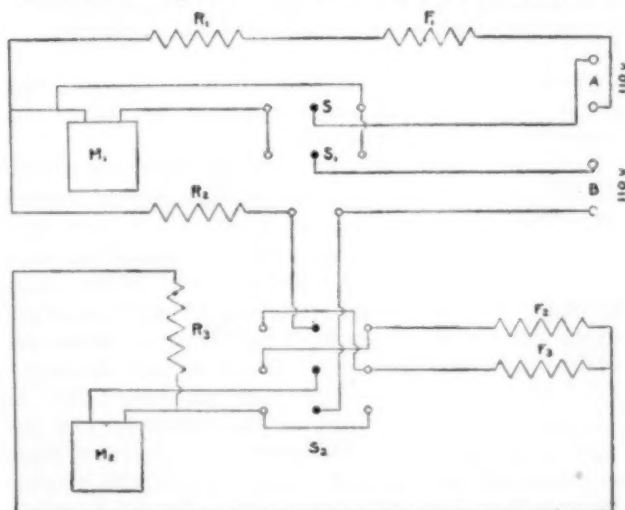


FIG. 4. A CONVENIENT PLAN OF ELECTRICAL CONNECTIONS FOR THE FURNACE WITH INDEPENDENT END COILS

simplifying the construction and regulation rather than of improving the temperature uniformity, since the latter could be obtained in several of the furnaces.

The final design is shown diagrammatically in Fig. 2. The end coils may be either crowded or uniformly wound, but the main central heater must be uniformly wound. Equally good compensation will result if the central heater has slightly crowded winding, but the resulting furnace is not as convenient to use over small ranges of temperature. For example, with a uniformly wound heater at a given temperature changes of ten degrees or so in the furnace temperature can be obtained by regulation of the central heater current without disturbing the compensation much, whereas in a central heater with crowded end windings, the same change in the current would have necessitated considerable adjustment of the end coil current. The end coils should be more closely wound than the center, thus increasing their resistance and lessening the danger of severe local heatings. The heaters are shown as independent units. This

<sup>7</sup>Am. J. Sci., 43, 175, 1917.

renders possible a variety of connections. In some of the writer's work the tube to be heated was very short and it was therefore desirable to heat the ends as little as possible. Satisfactory results were obtained by running the plug coils in series with the center coil and compensating by means of the end coils. In practically no experiments was a good compensation obtained by running the two end coils in series, as one end invariably required more current than the other.

The actual furnace is shown in Fig. 3. The large amount of insulation was necessary in order that a

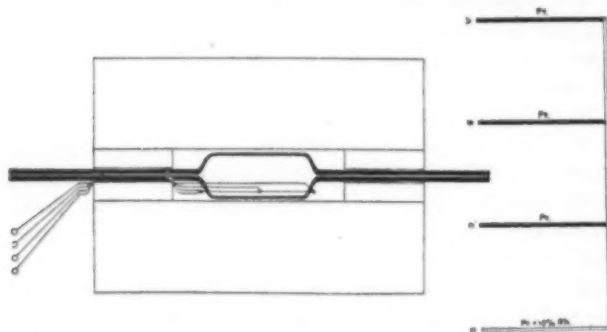


FIG. 5. SECTION OF FURNACE WITH GAS BULB AND COMPOUND THERMO-ELEMENT

FIG. 6. COMPOUND THERMO-ELEMENT

constant temperature might be maintained over long periods of time. The construction of the heater and plugs may be thus described:

**Heater.**—Two helically grooved alundum tubes were selected of such a size that the smaller readily slipped inside the larger and was of 6 cm. inside diameter. A coil of 0.8-mm. platinum wire was wound on each end of the smaller tube for a distance of 10 cm. from the ends, and the whole was covered with alundum cement and baked. When hard the excess alundum was removed until this tube would just slide into the larger tube. A hole was bored through the large tube at each end at the inner edge of the end coils, and the inner wire ends, which had purposely been left long, were brought out through these holes. The smaller tube was then slid into the larger and these ends drawn tightly through and then wound back on the outer tube to its ends. The central portion of the outer tube was then separately wound with similar wire and the whole covered with alundum cement and baked.\* This peculiar method of winding was found to be necessary because alundum cement is not as good an electrical insulator as many suppose. Two furnaces, constructed with uniform main heaters extending the full length of the tube and with end heaters wound around the main heater and insulated from it by 0.5 cm. of alundum cement, did not even survive their trial heats, as the current arced from the main to the end coils, burning them out.

**Plugs.**—The principal details may be observed in Fig. 3. The inner and outer alundum tubes were cemented to an alundum disc with water glass. The space between the tubes was filled with freshly ignited magnesia powder to within 1 cm. of the end and this magnesia held in place by means of a paper washer. The remainder of the space was filled with alundum

\*A smooth (1-cm. thick) alundum tube upon which the end coils might have been more closely wound than the center would have been easier to handle, but unfortunately was not available.

cement and the whole baked. In order to insure a good tight fit the outer alundum tube was usually coated with alundum cement, and when this had hardened the plug was filed down until it would just slide into the furnace. The inside of the outer edge of each alundum disc was covered with asbestos wool stuck on with water glass, thus insuring a tight fit when the plug was pushed home and eliminating any radiation losses through the crevices.

The use of alundum with burnt magnesia and fire-clay in all the hot portions of the furnace assures consistent results from the furnace day after day even at quite high temperatures with practically the same current. The calorox which forms the outer insulating layer is unsuitable at temperatures as high as 1000 deg. The outer shell is of sheet iron, painted with aluminium paint. We find that this paint reduces the total heat losses by reducing the radiation, thereby increasing the temperature of the shell and decreasing the temperature gradient across the insulation.

**Electrical Connections.**—As has already been stated, the exact method of making electrical connections will depend on the particular use that is to be made of the furnace. Three separate electrical controls will be almost always essential, although the current required by the end heaters will usually be very nearly of the same magnitude. The writer was able to take advantage of this fact in developing a set-up whereby all the adjustments could be obtained from two main circuits with

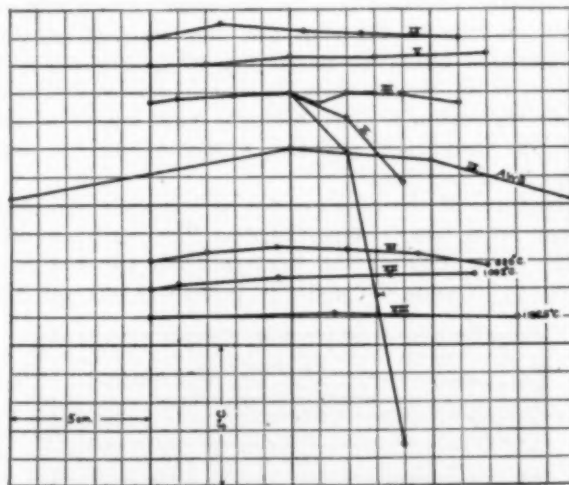


FIG. 7. TEMPERATURE UNIFORMITY

Curve I: Furnace with end plugs and uniformly wound heater. Curve II: Furnace with end plugs and crowded end windings on heater. Curve III: Furnace with flat end heaters similar to those used by Allen and Lombard, with slightly crowded windings on ends of main heater and with plugs. Curve IV: Furnace similar to III with exception that the furnace heater was uniformly wound and the plugs contained extra end heaters. Curve V: Furnace as described in detail in the text. (Curves I-V at approx. 1000 deg.) Curve VI: Furnace V at 620 deg. Curve VII: Furnace V at 1002 deg. Curve VIII: Furnace V at 1186.5 deg. Curve IX: Curve VII of Fig. 1 repeated. When compared with Curves I and II, in which likewise only unheated end plugs were used, an idea may be gathered of the adverse conditions under which the writer worked as compared with those of Gray.

considerable saving both of current and the operator's time.

A diagram of these connections is shown in Fig. 4. A and B are the two main circuits. In A the current always flows through the furnace coil  $F$ , and the variable resistance  $R$ , and can be made to pass through the ammeter  $M$ , by means of the switch  $S$ . In B the current has two routes, depending on the way the switch  $S$ , is



thrown. As in A, the current always passes through a variable resistance  $R_1$  and at will may be made to pass through  $M_1$  by means of switch  $S_1$ . The function of the three-way switch  $S_1$  is to place the variable high resistance  $R_1$  in parallel and the ammeter  $M_1$  in series with one of the furnace coils, either  $F_1$  or  $F_2$ , at will. If the switch  $S_1$  is thrown to the left and the switch  $S_2$  to the right the current follows the route  $S_1, M_1, R_1, F_1, R_2$  in parallel with  $F_2$  and  $M_2$ , and back. The upper ammeter shows the total current, i.e., current through  $F_1$ , and the lower the current through  $F_2$ . With this arrangement the current through  $F_1$  will always be equal to or less than the current through  $F_2$ , but by reversing the switch  $S_1$  the position of these furnace resistances is reversed and so all the required adjustments can be made. If nearly the same amount is required through both  $F_1$  and  $F_2$ , the amount wasted in  $R_1$  will be very small.

**Temperature Measurements.**—In the earlier work a single platinum-platinrhodium thermoelement tube was used. It was mounted in a Marquardt porcelain thermoelement tube having two small holes bored in the closed end, through which the wires passed; the junction was bare and bent so that it would come in contact with the gas balloon which was to be maintained at constant uniform temperature. The thermoelement tube could be inserted or withdrawn from the furnace and the measurements were always made when the tube was about to be withdrawn, since on inserting the tube the uniformity was somewhat disturbed. When the local heatings were found negligible this thermoelement was replaced by a compound element of the form shown in Fig. 6, by means of which direct or differential temperature measurements could be obtained at any one of three points with but four leads. Fig. 5 shows one of these later set-ups. At 1000 deg. no trouble with leakage was experienced, but at 1200 deg. it caused considerable trouble, especially whenever any part of the element came in contact with the hot alundum

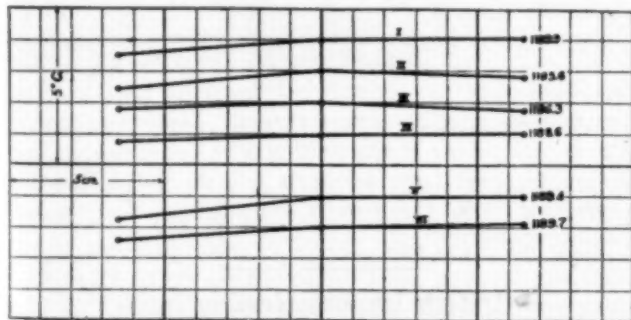


FIG. 8. TEMPERATURE UNIFORMITY. THESE CURVES REPRESENT THE FURNACE DISTRIBUTION OBTAINED DURING A SERIES OF EXPERIMENTS AT APPROXIMATELY 1190 DEG.

furnace tube, and necessitated careful shielding in the furnace itself. This was obtained by placing in the furnace a sleeve of thin platinum foil connected to the outer shield, and carefully insulating the same from the element itself by enclosing most of the latter in Marquardt porcelain. The measurements were made by means of the usual potentiometer set-up.\*

\*W. P. White, "Potentiometer Insulation, Especially for High Temperatures and Thermoelectric Work," *Physical Review*, XXV, 334-352, 1907.

In most of the investigations no greater uniformity than  $\pm 0.5$  deg. was necessary and no attempt was made to improve on this. The apparatus is undoubtedly capable of producing a uniformity of  $\pm 0.2$  deg., the limit set by local heatings, provided the experimenter is willing to take the trouble with the current adjustments.

Figs. 7, 8 and 9 are curves representing the results. Unfortunately furnace V was not used with the same set-up on different days, so that no comparison can be

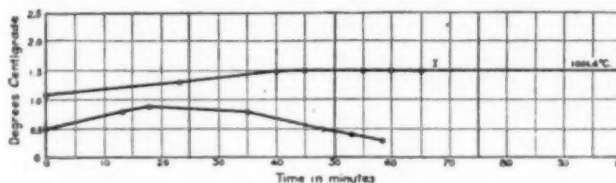


FIG. 9. TEMPERATURE CONSTANCY

Curve I: The fluctuations in the furnace temperature with time in part of a four and a half run with furnace IV at 1001.4 deg. Curve II: The fluctuations in the furnace temperature with time in a run with furnace V at approximately 1190 deg.

made of its performance on different days with the same current. At 1190 deg. with a porcelain tube 3 cm. in diameter at the center and somewhat smaller ends the current required on 110-volt circuit to give a uniformity of  $\pm 0.5$  deg. was: Left, 5.65; center, 5.50; right, 5.55 amp. Furnace IV was constructed of exactly the same material as furnace V although of different shape, and one may with reasonable certainty infer that if furnace IV would reproduce a given temperature uniformity furnace V would also. Table I gives the results obtained in four separate runs with furnace IV.

TABLE I.—ENERGY REQUIRED UNDER DIFFERENT CONDITIONS OF END RADIATION

Set Up	Date	Left Amp.	Center Coil	Right Coil	Temperature Distribution
Porcelain tube A.	Dec. 7, 1915	3.35	5.1	3.30	1001.0 $\pm$ 0.5°
	Jan. 6, 1916	3.35	5.1	3.35	1000.4 $\pm$ 0.5°
Transparent silica tube B.	Feb. 21, 1916	4.04	4.95	4.06	1000.0 $\pm$ 1.0°
	Mch. 15, 1916	4.05	5.02	4.06	999.5 $\pm$ 1.0°

Particular attention is directed to the great difference in the current required by the end coils in the two different set-ups. The heat lost by radiation through a transparent silica glass capillary tube of 1-cm. outer diameter and 1-mm. bore necessitated the increasing of the current in the end coils from 3.35 to 4.06, an actual increase of 0.71 amp., or 21 per cent, and confirmed the observation of Day and Sosman on the magnitude of the end radiation heat losses.

#### SUMMARY

The production of temperature uniformity in an electrically heated air column can best be accomplished by means of three independent heaters in addition to end plugs. The entire region to be heated should be surrounded by a layer of conducting material sufficient to smooth out any local heatings, and the whole furnace should be so insulated that the effect of non-uniformity in the temperature of the furnace surroundings is rendered negligible. The use of alternate layers of good and poor conductors will reduce the total amount of insulation necessary, but if constancy of temperature as well as uniformity is desired the insulation must be of such thickness as to eliminate the effect of temperature fluctuations in the furnace surroundings during the period the furnace is in use. This type of

furnace has the advantage that it may be converted into a simpler type if less uniformity is adequate by merely changing the mode of connecting the heaters.

A furnace embodying these principles is described in detail. This furnace yielded a temperature uniformity of  $\pm 0.5$  deg. at temperatures ranging from 620 to 1190 deg., and at 1000 and 1190 deg. a temperature constancy of  $\pm 0.25$  deg. for periods of time exceeding an hour. With greater care in adjustment a uniformity of 0.2 deg. should be possible, and without doubt the furnace could be run at much higher temperatures without great loss in efficiency. The furnace is economical of current and will reproduce practically the same conditions on different days with the same amount of current provided the temperatures are below that at which magnesia powder begins to pack.

Some results indicative of the behavior of several different furnaces and set-ups are presented for their comparative value and also with the view of indicating the magnitude of some of the effects obtained.

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### Exports of Glycerine in 1918

The Department of Commerce, through the Division of Statistics, gives out the following figures of the exports of glycerine to all countries during the calendar year 1918:

Countries	Lb.	Value	Countries	Lb.	Value
France.....	3,100	\$2,530	Dominican Republic.....	1,476	\$1,145
Italy.....	12,133,339	6,163,011	Argentina.....	512	354
Norway.....	50	35	Bolivia.....	2,515	2,001
Portugal.....	100	72	Brazil.....	1,493	998
Spain.....	56	38	Chile.....	10,121	7,134
England.....	6,575,725	3,728,718	Colombia.....	4,026	3,115
Scotland.....	246,795	144,354	Ecuador.....	1,552	968
Ireland.....	224	161	British Guiana.....	2,495	1,859
Bermuda.....	50	38	Dutch Guiana.....	120	101
British Honduras.....	46	41	Paraguay.....	20	18
Canada.....	1,851,937	1,107,249	Peru.....	2,886	2,309
Costa Rica.....	403	289	Uruguay.....	1,050	723
Gautemala.....	1,209	930	Venezuela.....	5,412	3,583
Honduras.....	441	376	China.....	7,667	5,562
Nicaragua.....	677	511	Chosen.....	87	24
Panama.....	3,653	2,392	British India.....	1,480	1,007
Salvador.....	954	718	Dutch East Indies.....	105	73
Mexico.....	13,331	10,645	Hongkong.....	200	143
Newfoundland and Labrador.....	400	279	Japan.....	831,768	540,016
Barbados.....	450	321	Other British Oceania.....	2	2
Jamaica.....	250	197	French Oceania.....	28	23
Trinidad.....	1,158	817	Philippine Islands.....	10,503	6,664
Tobago.....	270	214	British South Africa.....	7,885	6,066
Other Brit. West Indies.....	25,516	17,959	British East Africa.....	35	20
Cuba.....	175	71	Portuguese Africa.....	27	15
Danish West Indies.....	221	168	Total.....	21,754,728	\$11,766,636
Dutch West Indies.....	227	185			
French West Indies.....	506	394			
Haiti.....					

### Imports of Platinum Into the United States

The following table shows the imports of platinum into the United States during the fiscal year ended June 30, 1918, by countries of origin:

Country	Unmanufactured		Ingots, Bars, Plates, Etc.		Vases, Retorts
	Troy Oz.	Value	Troy Oz.	Value	
France.....	166	\$18,142	814	\$78,674	\$165
Netherlands.....	1,073	80,834	357	29,614	1,682
England.....	76	7,249	253	23,671	.....
Canada.....	372	35,254	.....	.....	.....
Panama.....	9	749	.....	.....	.....
Mexico.....	27	2,312	.....	.....	.....
Cuba.....	3	300	.....	.....	.....
Brazil.....	25,365	2,112,211	1,665	129,533	700
Chile.....	3	300	.....	.....	.....
Colombia.....	162	12,960	.....	.....	.....
Peru.....	489	38,207	.....	.....	.....
Venezuela.....	21,000	2,000,000	.....	.....	.....
China.....	.....	.....	25	2,344	.....
Russia in Asia.....	.....	.....	.....	.....	.....
British South Africa.....	.....	.....	.....	.....	.....
Total.....	48,745	\$4,308,518	3,117	\$264,096	\$2,547

### Improved Treatment of Burns

THE war that has so recently closed has been no exception to those of the past in that all the medical and surgical arts were most intensively developed. Notable among the successes was the treatment of burns by Barthe de Sandfordt, who had spent sixteen years in trying to overcome the prejudices of the medical fraternity to his closed wax seal treatment. It was only when the hospital at Issy les Moulineaux was filled with many patients suffering with burns that it was considered advisable to depart from the usual practice and prove out this method experimentally.

The paraffine wax composition, called ambrine by de Sandfordt, is sprayed on the wound at 140-150 deg. F. and then absorbent cotton is plied on alternately with wax layers. The aggregate of wax and cotton seals the wound and thermally insulates it as well, the temperature of the ambrine at the skin being found to be 106 deg. F. for several hours after each 24-hr. dressing. This method is actually a case of incubation, wherein the flesh and skin cells propagate themselves in a most remarkable manner. However, all infection and bacteria must be excluded if present by some such means as Dakin's hypochlorite solution with Carrel's technique, or the incubation of flesh and skin cell destroying bacteria will result, with the balance sheet showing nothing but loss. Fresh burns, being sterile, of course are ideal for the ambrine treatment, and it has been with them that the most marvelous cures have been made.

The warm dressing has an additional virtue in that it draws the fire instantly from the wound and allows the patient to become normal. Dr. R. C. Casselberry treated the 75 employees burned at the Essington, Penn., powder explosion and reported the advantages of the ambrine treatment as:

Relief from pain to a great degree.

Cleaner and more comfortable.

Fewer scars and contractions.

Skin grafting rare.

More rapid healing.

Superior in every way to other methods commonly used.

The Army surgeons have had such marvelous success with ambrine in treating all sorts of burns that it became necessary to establish the Ambrine Laboratories, 347 Madison Ave., New York City, to supply the demand. All manufacturing plants dealing with hot materials and having frequent burn accidents will do well to become acquainted with the results reported in the current medical literature.<sup>1</sup>

### British Import Restrictions

On March 4, the War Trade Board announced that individual import licenses were required for the importation of dyestuffs into the United Kingdom. The list included all synthetic dyes, intermediates and color lakes, in paste, powder, solution, or any other form.

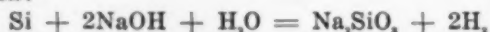
Later it was announced that, for the present, general licenses will be granted for the importation of products covered by the prohibition if they are of bona fide French, American or Swiss origin. These licenses will be modified as domestic manufacture develops, so that only essential colors and intermediates will be permitted to enter the country.

<sup>1</sup>Surgery, Gynecology and Obstetrics, Vol. XXVI, No. 4. Page 450, April, 1918, "Treatment of Burns," Dr. W. O. Sherman.



## Production of Hydrogen and Water Glass by the Silicol Process

SEVERAL years ago George F. Jaubert described<sup>1</sup> the military methods in use at that time for the production of hydrogen, among which the reduction of water by silicon was of chief importance for military purposes such as for dirigibles, etc. Siemens and Schuckert were the original investigators and worked out a process<sup>2</sup> for the production of hydrogen from the reaction:



Initially steam was employed, but later it was found that the heat of solution of the caustic was sufficient

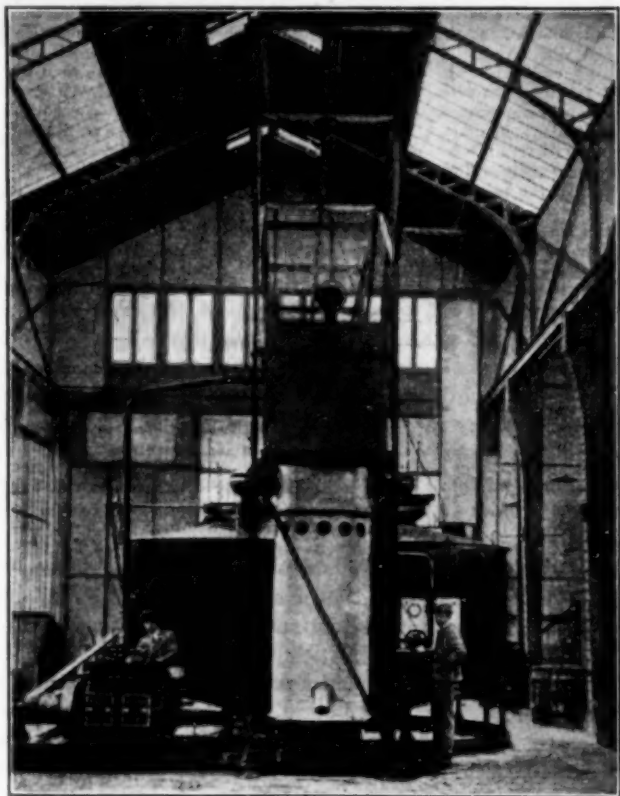


FIG. 1. GENERAL VIEW OF THE BRITISH ADMIRALTY HYDROGEN PLANT

to start the reaction and that it would maintain itself thereafter. The process was a chemical success, but due to the high price of silicon, was not economical.

In order to reduce the costs of the pure silicon, Captain H. Lelarge substituted silicon alloys in the process, successfully operating the reaction with a silicon iron containing as little as 18 per cent silicon. However, the 50 to 80 per cent ferrosilicons were much preferable. *Engineering* in its Jan. 24 issue gives a description of one of the British Admiralty hydrogen gas plants, the production of which in peace times may be utilized in oil refining by the water-glass method and hardening by hydrogenation, offering an outlet for both the sodium silicate and the hydrogen at abnormally low costs.

The plant operates the silicol process, which consists

<sup>1</sup>Memoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils de France, Vol. II, 1911, pages 45-107.

<sup>2</sup>Brevet français Nos. 406,930, 1910.

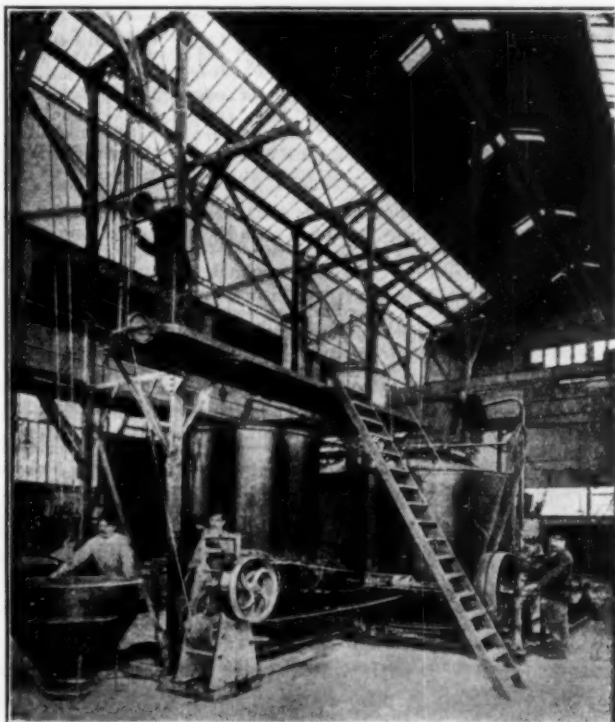


FIG. 2. PUTTING SODA IN THE HOPPER

in the decomposition of silicon alloys obtained in the electric furnace, such as ferro- or mangano-silicon, or even silicospiegel, by a concentrated solution of caustic soda (35 per cent to 40 per cent of NaOH). In the silicol process, the silicon alloys are made to act on a caustic alkali solution having a high boiling-point, the object being to retain in the solution itself all the heat

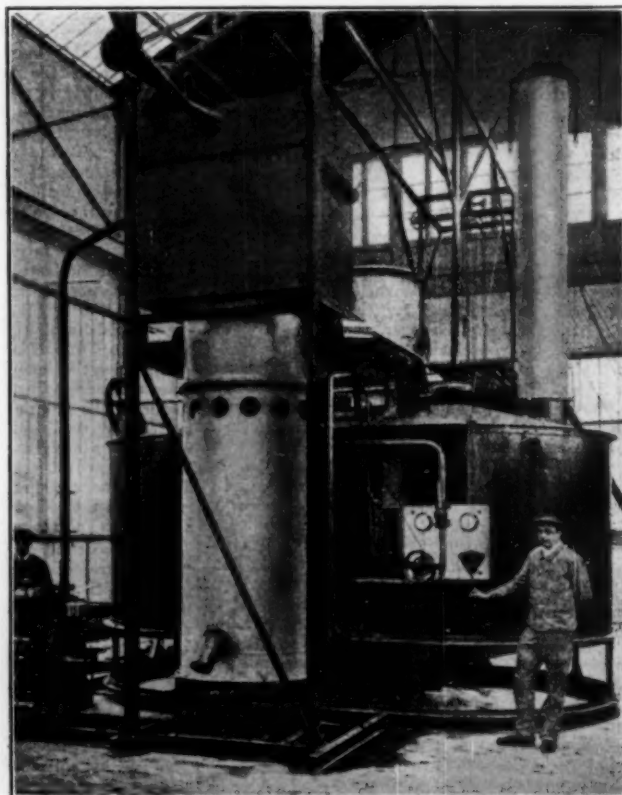


FIG. 3. WATER GAGE AND VALVE OPERATING GEAR

generated by the reaction in the combination of the silicon with the alkali, thus doing away with all outside heating.

The installation contains a vat provided with a stirring device for preparing the caustic soda solution. The lower part of the vat is fitted with a pipe provided with a valve and ending in a gas generator; the latter is fitted with a "planetary stirrer," and has at its top part a receiver containing the silicon alloy. The receiver has a hopper-shaped base in which acts a distributor worked by a crank.

The plant operates as follows. Soda in lumps, in pieces of cylindrical shape or in slabs, is put in a vat, to the extent of one and a half times or double the weight of soda to that of water; the stirring device is started running and the dissolution of the soda takes place, the heat thereby evolved being sufficient to raise the temperature to about 60 deg. or 80 deg. C. The solution is then led into the gas generator, which it should reach at a temperature sufficient to start the reaction on contact with the silicon alloy. The "planetary stirrer" causes the silicon alloy powder falling from the hopper-shaped base of the receiver to come into intimate contact with the caustic soda solution, and prevents it from accumulating in the center of the generator. The hydrogen gas, which is evolved at a high temperature, flows into a scrubber-condenser, where it loses the water vapor it contains and is cooled at the same time. The hydrogen gas then flows out through a pipe for utilization. Fig. 2 shows the soda being put into the hopper shown to the left of the view, the hopper being then raised and placed in the vat. Fig. 3 shows the water gage; Fig. 4 the starting of the water pump, and Fig. 5 the turning of silicospiegel preparatory to its utilization in the silicol process.

The water used for cooling the gas in the scrubber-condenser, which leaves this at a temperature close upon

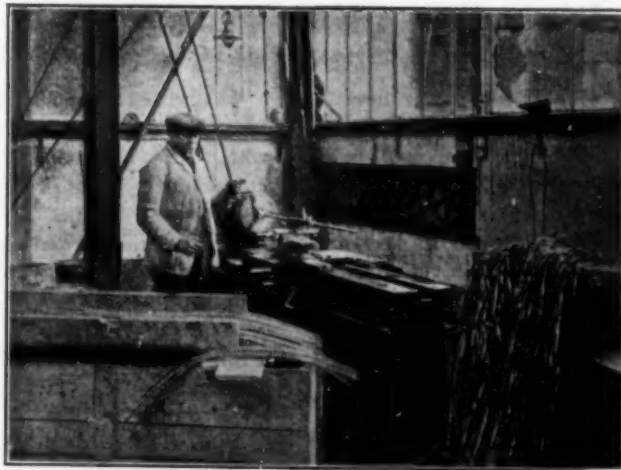


FIG. 5. TURNING THE SILICOSPIEGEL FOR USE IN THE PLANT

boiling-point, is recovered, and is utilized in the vat or in the gas generator as needed.

The advantages of the silicol process lie in the use of a silicon alloy in which the cost of the unit of silicon is a low one compared with that of the industrially pure silicon hitherto used for the same purpose, this leading to a great reduction in the cost price of the hydrogen gas. In installations where a weak solution of caustic soda is used, a neutral silicate of soda is formed, while when working, as is the case in the plant we illustrate, with a concentrated solution, an acid silicate poorer in soda is obtained; this leads to a saving in caustic soda and allows the obtaining of non-caustic residues which can be utilized for dyeing and bleaching.

The water-gage can be suitably connected to the powdered silicon alloy distributor so as to cause the delivery of the alloy powder to vary automatically with the consumption. The alloys which have given good results are the various grades of ferrosilicon, manganosilicon and silicospiegel. One single silicol plant of the type referred to can fill in half a day the largest type of dirigible, producing at the rate of 60,000 cu.ft. per hour.

As the silicol process was considered initially to be limited to military work, no patents were taken out in the United States by the inventors. The time limit has now expired and there is no doubt that full advantage of this economical process will be taken by many oil refiners. Hydrogen has been found to be a most satisfactory sweeping gas for deodorizing purposes, not having the tendency to hydrolyze the oil and thus giving a sweeter product than can be obtained with superheated steam. In producing neutral oil with water glass, the foots separate readily and give an excellent soap powder stock, sufficient bicarbonate being added to destroy the excess water glass content and produce a fine silica grain filler.

The process often may prove economical in plants where only the hydrogen is consumed and the water glass sold in the vicinity. By recovering a larger part of the caustic soda with a mercury cell, the process might be made cyclic. The diminished alkali content in the water glass would be advantageous for most purposes, especially in oil refining.

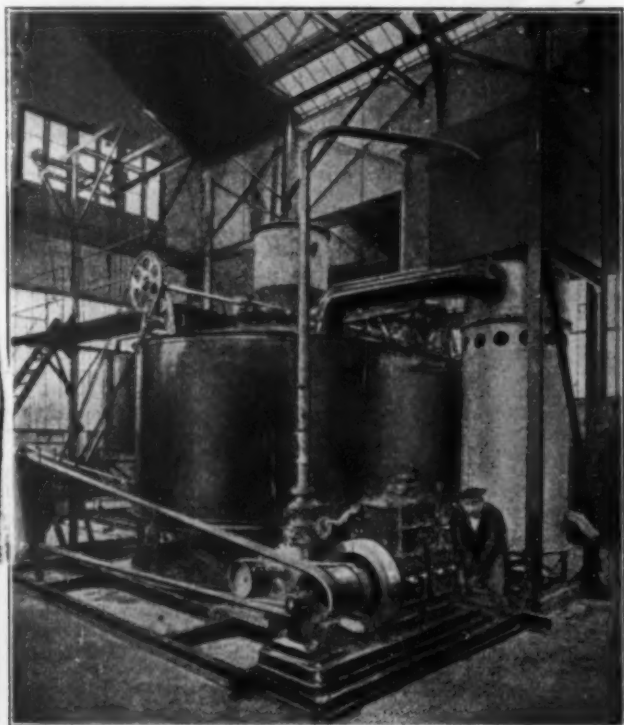


FIG. 4. STARTING THE WATER SUPPLY PUMP



## Fuel Economy in the Boiler House—III\*

A Description of the German Types of CO<sub>2</sub> Recorders Which Depend on Measurements of the Physical Properties of Flue Gases—Thermoscope, Arndt's Gas Balance, Krell, Telezometer, Haber-Loewe Refractometer Instruments—Checking Recorders With Orsat Apparatus

By J. B. C. KERSHAW

**A**LTHOUGH the CO<sub>2</sub> thermoscope is neither continuous nor recording in its action, it may be briefly mentioned here, for the principle upon which it is based is capable of application to a recording type of apparatus. The instrument is shown in Fig. 1, and depends for its action upon the heat generated when carbon dioxide gas is brought into contact with dry caustic soda, the chemical reaction which ensues leading to a generation of heat which is proportional to the percentage of CO<sub>2</sub> contained in the gas sample. The instrument consists of a cylinder fitted with a plunger, by means of which a definite and measured volume of the gas from the flue is drawn into the cylinder. This gas is then forced by the downward movement of the plunger through a small cartridge containing dry pulverized caustic soda. A thermometer is placed on the instrument with its bulb so constructed that it forms a jacket to the caustic soda cartridge, and therefore records accurately the amount of heat generated. A movable scale is attached to the inside of a slot in the cylinder, and by the aid of this the percentage of CO<sub>2</sub> is read off directly.

### THE ARNDT GAS BALANCE OR "ECONOMETER"

In Fig. 2 is illustrated the Arndt gas balance or "economometer," which, as its name implies, is designed for the purpose of weighing the waste gases which pass to the chimney, the record obtained being a continuous and not an intermittent one. If placed in a conspicuous position in the boiler house, the variations in the weight, and therefore in the percentage of CO<sub>2</sub> in the gases, can thus be easily seen and noted. The action of the Arndt gas balance is based upon the known fact that carbonic acid gas is one and a half times heavier than air, the respective weights of one liter being 1.97 and 1.29 grams. An increasing percentage of CO<sub>2</sub> in the waste gases will therefore be indicated by an increase in their density, and if there be no moisture present, the variations in density may be employed as an index of the CO<sub>2</sub> contents of the gases.

The method of operation of the instrument is as follows: The gases are drawn continually from the flue at *E*, by means of the steam jet *D*. On their way through the apparatus they pass first through the filter *A* and drying tubes *B*, and then through the weighing bulb *C*. The scale of the balance is graduated so that the percentage of CO<sub>2</sub> can be read off directly, and if it is desired the instrument can also be provided with a recording attachment of the usual type, so that a permanent record of the variations can be obtained.

\*The previous articles appeared in *CHEMICAL & METALLURGICAL ENGINEERING*, Vol. 20, No. 4, Feb. 15, 1919, and Vol. 20, No. 5, March 1, 1919.

### THE KRELL CO<sub>2</sub> RECORDER

Fig. 3 shows the Krell CO<sub>2</sub> recorder, which is closely allied to the Arndt gas balance in principle, although in this case a very delicate differential pressure gage is employed to determine the difference in weight of measured volumes of the flue gas and air. This gage is attached to two columns of equal height, the one containing air and the other the sample of flue gas. The pressure gage readings are taken by means of a slightly inclined glass tube, filled with colored alcohol, which projects from the side of the gage box or case. The height of this thread of colored alcohol varies with the pressure, and by means of a scale, marked in the percentages of CO<sub>2</sub>, corresponding to certain pressures, the amount of this constituent if the flue gas can be read off at any time. The apparatus is usually provided with accessories by means of which the position of the end of the thread of colored liquid is continuously photographed on a recording cylinder, and thus a permanent record of the CO<sub>2</sub> variations is obtained.

### THE TELEZOMETER RECORDER

The principle upon which the Telezometer recorder is based is similar to that of the Krell recorder—the variations in pressure caused by the differences in density of the ordinary air and of the flue gases being measured and recorded. The gases in this case are drawn by two centrifugal fans worked by a constant speed electric motor, through the bells marked 1, 2, 3 and 4 in Fig. 4. In this figure the bells are shown diagrammatically floating in separate vessels, but in the real instrument 1 and 2 are immersed in one tank, and 3 and 4 in another, paraffine oil being employed as containing fluid.

The differences of pressure cause movements of the lever *W*, which are transferred to the pen *T*, and a record of this movement is obtained upon the clockwork chart shown at *X*. The regulation of the inlet and outlet pressures of the air fan is carried out by means of a pin-valve, and by aid of this the instrument is adjusted to the zero position, when both fans are circulating air through the bells.

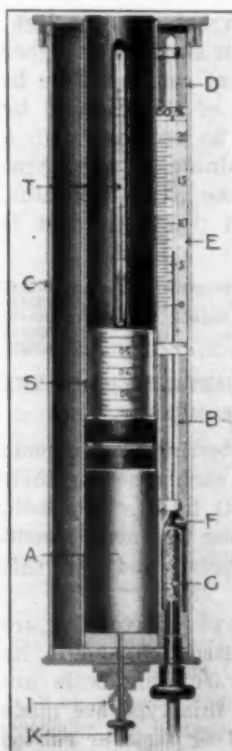


FIG. 1. THE CO<sub>2</sub> THERMOSCOPE

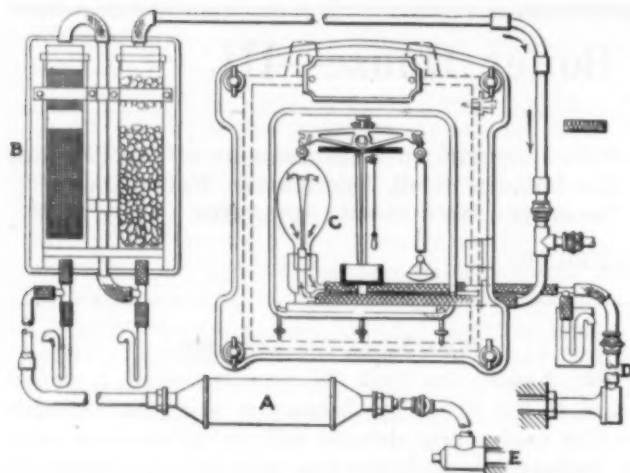


FIG. 2. ARNDT'S GAS BALANCE OR ECONOMETER

#### THE HABER-LOEWE REFRACTOMETER

The Haber-Loewe refractometer is based upon the measurement of the refractive index of the mixed gases. The method is therefore an optical one and resembles the optical methods for determining temperatures. The refractometer is illustrated in Fig. 5, and consists of the following essential parts: a prism, a telescope and a microscope. The gas to be tested is drawn through the prism, which is made of varnished metal and is provided with windows on opposite sides for the incident and reflected rays of light to enter and escape. The gas used for comparison flows through a casing. When an observation is being made with the instrument, the observer sees in the field of vision a scale, which is partly illuminated and partly in darkness. In pure air the boundary of the dark zone would coincide with zero on the scale, in air containing 0.9 per cent CO, this boundary would coincide with 1.0 on the scale, and the line of demarcation between the light and dark zones would be still further shifted for higher percentages of CO. The instrument can therefore be graduated to yield the percentage of CO, directly by observation, and if desired it can be provided with a photographic attachment for obtaining a permanent record, similar to that used for the Krell apparatus. The refractive indices upon which the instrument is based are the following:

Hydrogen.....	1.000139	Carbon monoxide.....	1.000340
Aqueous vapor.....	1.000261	Methane.....	1.000444
Oxygen.....	1.000270	Carbon dioxide.....	1.000452
Dry air.....	1.000291	Acetylene.....	1.000610
Nitrogen.....	1.000297	Ethylene.....	1.000678

#### COMPARATIVE ADVANTAGES AND DISADVANTAGES OF THE VARIOUS TYPES OF INSTRUMENTS

The first seven automatic gas-testing instruments described in Article II depend in each case for their action upon the absorption of the CO, by caustic potash, caustic soda or caustic lime and upon the measurement of the change in volume of the gas before and after this absorption.

The chief advantages of this type of recorder are that it is generally simple in construction and in its method of operation and that its running costs are low. Some of the instruments of this type are made entirely of metal and possess no glass parts or rubber connections, points in their favor which will appeal to all engineers, though not to chemists, who prefer to see

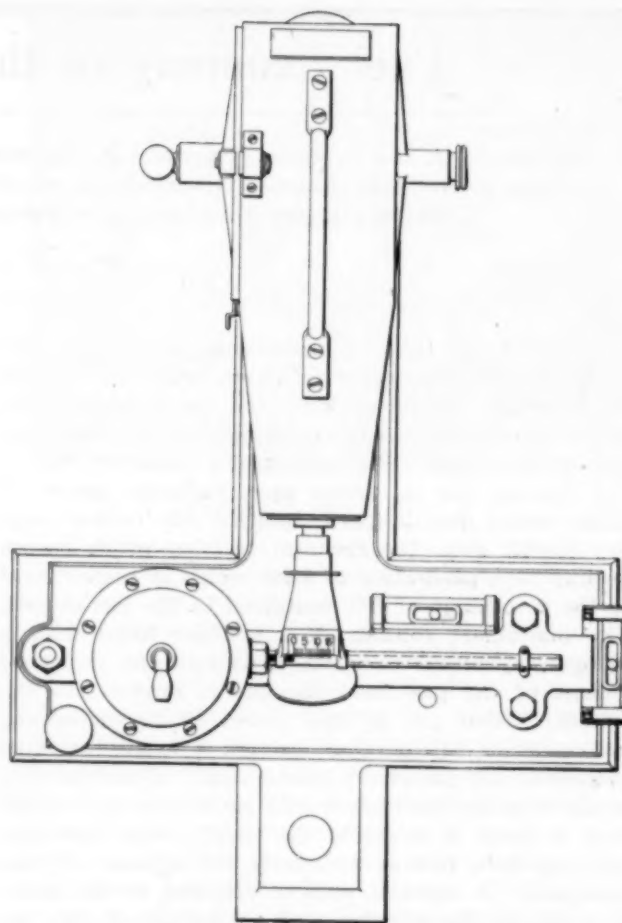
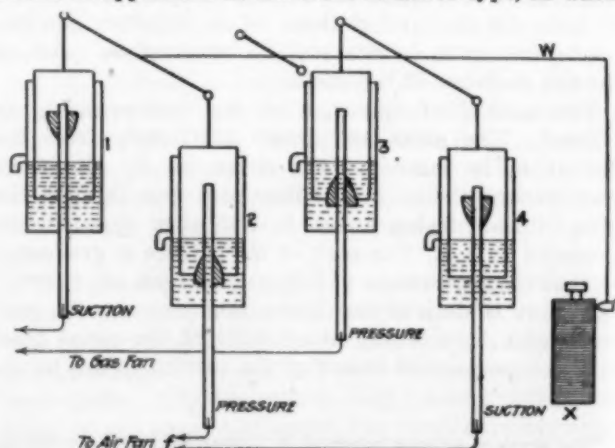


FIG. 3. PLAN OF THE KRELL CO. RECORDER

the inside of any apparatus they employ. For use therefore in those works where the gas-testing is in the hands of engineers the Simmance-Abady and bi-meter recorders are probably the most suitable and the least likely to get out of order, while the Webster "combustion indicator" is another instrument with metal parts which has found favor with engineers in the north of England.

One of the disadvantages, however, of employing metal with caustic potash solutions is referred to on page 45 of the Report of Barkley and Flagg's investigation (Bulletin No. 91, Bureau of Mines, 1916) and it is therefore not surprising that chemists prefer the forms of apparatus of the Ados or Sarco type, in which

FIG. 4. THE TELEZOMETER CO<sub>2</sub> RECORDER



only glass and rubber are employed for construction of the principal parts of the instrument.

As regards the choice of absorbing media, the bimeter recorder, which uses caustic lime, is under present conditions much the least expensive to work, for caustic potash has increased enormously in price since the war, and it has been replaced in many instances by the cheaper but less satisfactory sodium hydrate.

The last five gas-testing instruments described in

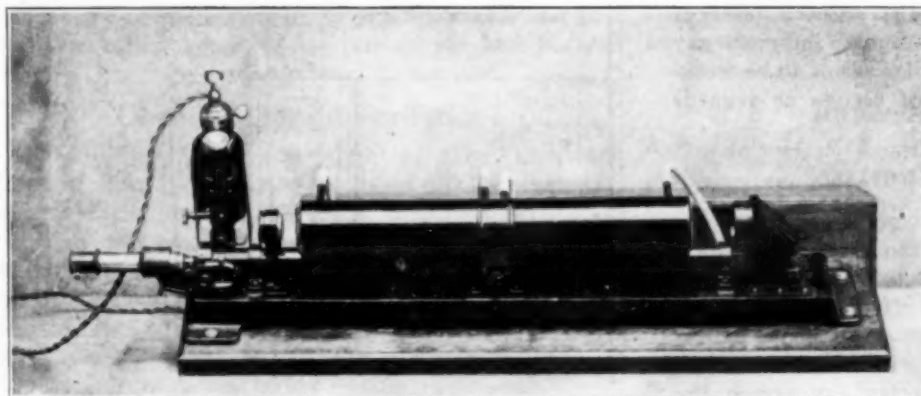


FIG. 5. THE HABER-LOEWE REFRACTOMETER FOR TESTING FLUE GASES

this article depend upon the measurement of some physical property of the waste gases, such as weight or refractive index, and do not require any absorbing medium for the  $\text{CO}_2$ . They are therefore cheaper to operate than the other type of instrument, for not only is the cost of caustic potash or other chemical saved, but the time taken up by recharging is dispensed with. Instruments of this type, however, call for more skill and scientific knowledge in their handling and control, and are more adapted for scientific observations and investigations than for regular use in the boiler house. It is noteworthy, and perhaps characteristic, that the more practical forms of apparatus depending upon the absorption of the  $\text{CO}_2$  are chiefly of English and American design and manufacture, while those based upon the very exact measurement of some physical constant of the mixed gases are of German origin.

#### CHECKING THE RESULTS OBTAINED BY THE AUTOMATIC RECORDERS

The great advantage of automatic gas-testing apparatus is that it enables a constant and continuous check to be kept on the work of the stokers in place of an intermittent one, and also that it enables the chemist or chemical engineer in charge of the boilers to obtain hundreds of tests upon which to base his judgment of the efficiency with which they are being worked, in place of the few that would be possible without its aid.

As already pointed out, however, the records obtained by the automatic apparatus are not absolutely trustworthy when the boilers are being operated with a narrow margin of excess air, and at other times the  $\text{CO}_2$  percentages recorded are too low, owing to the exhaustion of the caustic potash solution or to some other cause. The chemist or chemical engineer in charge of the boilers ought therefore to have an ordinary Orsat gas-testing set in regular use for taking and testing snap-samples of the waste gases, and when discrepancies

have been found between the results of these snap-tests and the continuous records obtained by the automatic apparatus, the cause of these differences should be at once investigated and remedied. The Orsat gas-testing apparatus, in its latest form, has been illustrated and described before in these pages, and there is no need to repeat the description in this article; a few notes, however, upon its use for checking the automatic gas test results may be useful.

In the first place it is better to keep the Orsat apparatus in the laboratory and to collect the gas samples to be examined by the dry method in the usual form of gas-sample tube, holding 220 cc. and provided with glass stopcocks at each end. Fig. 6 shows a sampling tube of this type (A) connected to the small rubber hand pump (C) and valve (B) by aid of which snap gas samples can be collected at any point in a few minutes. About six times the volume of gas contained in the sampling tube must be aspirated through it in order to

remove all the air, and by measuring the volume of water sucked in by one compression of the hand pump it is possible to calculate how many compressions are necessary to aspirate 1400 cc. of air or gas.

When the gas is very smoky, it is advisable to put a plug of glass-wool in the tube connecting the sample

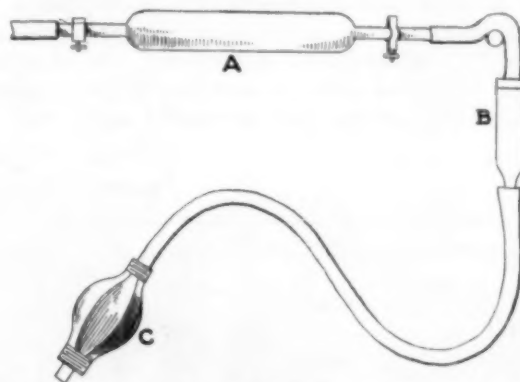


FIG. 6. GAS SAMPLING TUBE AND PUMP WITH CHECK VALVE

tube to the flue or other point whence the gas is being drawn. Half-a-dozen gas samples can be collected in this way with a minimum expenditure of time and trouble, and if the date, hour and place where taken be marked on the label of each tube, the actual testing can be deferred to any convenient time. With the stopcocks closed, the tubes are quite gas-tight and since no water or other liquid is present, beyond that which is contained as moisture in the gas, no absorption of the  $\text{CO}_2$  or  $\text{CO}$  can occur, even if the sample be kept for hours before testing. The tubes, however, must not be placed in direct sunlight while their contents are waiting to be tested, as this may produce chemical changes in the gases.

For checking the work of  $\text{CO}_2$  recorders the samples

must be taken from a point in the connecting tube between the filter and the automatic apparatus, as close to the latter as possible, a T piece being fixed permanently here, with a glass stopcock, for this purpose. The two tests of the automatic apparatus, the one just before and the other just after the period when the sample was withdrawn, should be noted on the label of the sample tube, together with the number of the recorder and the time and date of sampling, so that even when a large number of check tests are being carried out at one and the same time there will be no danger of confusing the results. Check tests of this kind should be carried out at regular intervals, say weekly, and also whenever a recorder seems to be working badly or is giving unexpected results as regards the percentages of  $\text{CO}_2$ .

#### FREQUENT CHECKS ADVISABLE

When the boilers are being worked with a very narrow margin of excess air, in the attempt to attain high efficiencies, that is, with 12 to 14 per cent  $\text{CO}_2$ , it will be necessary to test more often with the Orsat apparatus, for if carbonic oxide gas or unburned hydrocarbon gases be allowed to escape with the waste gases, the heat losses from this cause may far exceed the heat saved by reducing the excess air.

An empirical method of judging, from the results of the  $\text{CO}_2$  and oxygen tests, whether any unburned or imperfectly burned gases are present, is given below, but it is better, of course, to carry out the complete gas analysis and to estimate the carbon dioxide, carbon monoxide, oxygen and hydrocarbons separately in the gas mixture.

The use of the combustion method of determining the carbon monoxide and hydrocarbons is preferable to the methods depending upon absorption by cuprous chloride and fuming sulphuric acid respectively. In this case, only two absorption solutions and pipettes are required, namely, caustic potash and pyrogallous acid, and the

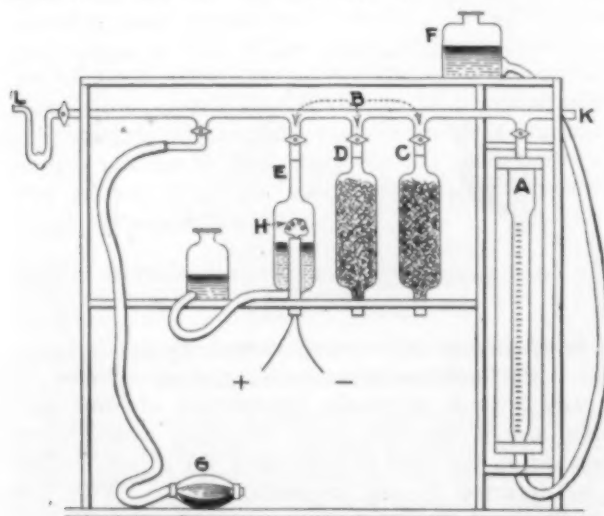


FIG. 7. IMPROVED ORSAT GAS-TESTING APPARATUS

Orsat apparatus can be reduced in bulk and size, and its operation much simplified. Details of the modified apparatus (see Fig. 7) will be found in the Handbook named below.<sup>1</sup>

<sup>1</sup>"Fuel, Water and Gas Analysis for Steam Users," by J. B. C. Kershaw, 2nd edition. Constable & Co., 1913.

#### AN EMPIRICAL METHOD OF DETERMINING WHETHER UNBURNED GASES ARE PRESENT IN THE WASTE GASES FROM BOILERS

Air contains by volume 79 per cent nitrogen and 20.8 per cent oxygen. When burning a bituminous fuel of average quality, yielding 35 per cent volatile matter when heated, about 1.8 per cent. of the oxygen

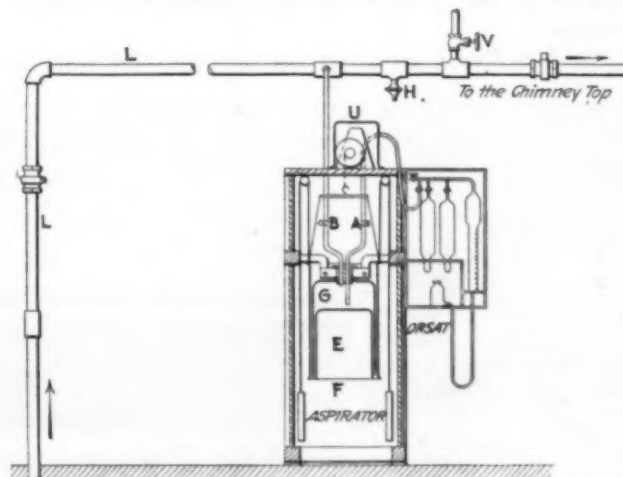


FIG. 8. SAMPLING APPARATUS FOR FLUE GASES, USED IN HAMBURG

of the air will be required to complete the combustion of the hydrogen contained in the coal; the air that remains will therefore contain only 19 per cent of free oxygen. Now any volume of oxygen yields the same volume of  $\text{CO}_2$  on combustion, and the tests for carbon dioxide and for oxygen, when added together, ought therefore to total 19 per cent. If there be a continued deficiency in the two tests when dealt with in this manner, it indicates that carbon monoxide or hydrocarbon gases are also present in the exit gases. When burning coke or anthracite fuels, which contain only a small percentage of hydrogen and volatile hydrocarbons, this disappearance of oxygen does not occur. The  $\text{CO}_2$  and oxygen tests of the waste gases in such cases, when added together, should equal the original oxygen contents of the air, namely 20.8 per cent.

#### AN AUTOMATIC SAMPLING APPARATUS FOR OBTAINING AVERAGE SAMPLES OF THE WASTE GASES

When the boilers are being regularly worked with the minimum amount of excess air, it is advisable, however, to institute some more regular and systematic method of checking the presence of unburned gases than that afforded by occasional snap samples, and it is wiser to install the continuous form of sampling apparatus described below. This apparatus was introduced by the Hamburg Smoke Abatement Society some years ago, in connection with the system of boiler control worked in that town and its environs, and it is stated to have given good results, more than 400 boilers under the control of the society having been equipped with it. The apparatus is shown in diagram form in Fig. 8.

The sample of gas is drawn continuously, using natural or artificial draught, from the exit-flue by means of the pipe L, and as it passes over the aspirator F a small proportion of the gas flow is sucked down into this by the action of clockwork on the bell E. The aspirator above this bell is filled with water covered with a film



of paraffine oil,<sup>2</sup> and the rate at which the bell sinks and the gas is sucked into the space *G* above it is controlled by a pendulum and simple clockwork arrangement at *U*, the speed of which can be varied to suit the length of the firing shift. At the end of twelve or eight hours (i.e. when the firemen change) the clockwork is stopped and the average sample of gas stored in the space *G* is tested for carbon dioxide and for oxygen, by aid of the Orsat apparatus shown on the right-hand side of the aspirator, a rubber tube being employed to connect the aspirator and the Orsat apparatus. Two tests of the average samples of gas are made, and the aspirator is then emptied by raising the bell *E*, and

by opening the tap *A* and the two taps shown at the entrance to the Orsat apparatus.

By closing *A*, and opening *B*, and by starting the pendulum of the clockwork again, the apparatus is set for taking the next average sample, no attention being required again for eight or twelve hours, according to the length of the working shift. The pipe *L* is kept free from soot and rust deposits by blowing steam or compressed air through it, by means of the tap at *V*, and snap samples of the exit gas can be taken when desired without stopping the aspirator, by connecting the cock at *H* with the tap at the entrance to the Orsat apparatus, by means of a thick rubber tube.

## Chemical Trade Statistics

The foreign trade committee of The Chemical Alliance, Inc., is preparing a digest of the chemical export statistics of the seven chemical producing countries the combined exports of which represent 90 per cent of the world's business. Six of these require recalculations from foreign values, weights and measures into our standards. The 100 items to be listed are:

### ACIDS AND HEAVY CHEMICALS

Muriatic acid	Chromates
Sulphuric acid	White lead
Nitric acid	Blanc fixe
Acetic acid and acetates	Zinc oxide
Glauber's salts	Zinc dust
Blue vitriol	Lithopone
Green vitriol	Barium salts
White vitriol	Barium chloride
Litharge	Barium nitrate
Alum and aluminium	Barium peroxide
Sulphate	Chloride of zinc
Sodium nitrate	Barytes
Sulphur	Epsom salts
Manganates and permanganates	Phosphates of soda
Water glass	Niter cake
Sugar lead	Sal ammoniac
Zinc chloride	Sulphides of soda and potash
Tin salts	

### COAL AND GAS BY-PRODUCTS

Gas liquor	Naphthalene
Oxalic acid	Anthracene
Ammonium sulphate	Phenol (carbolic acid phenyl alcohol)
Coal tar, coal tar oil and coal tar products	Cresol (methyl phenol so-called 100 per cent crude carbolic acid of commerce)
Coal tar pitch	
Benzol (coal benzene)	
Other light, coal tar oils (cumol toluol), etc., carburetted hydrogen, anthracene oil, carbolic oil, cresote oil and other heavy coal tar oils; mineral naphtha (asphalt naphtha)	

### ELECTROCHEMICALS

Bromine and bromides	Phosphorus	Bleaching powder
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### FERTILIZERS

Phosphates of soda	Natural phosphates of lime
Superphosphates	All other fertilizers

### MISCELLANEOUS CHEMICALS

Chrome alum	Cyanides
Ultramarine and like blues	Prussian and like blue
Guinecotton pyroxyline	Insecticides
Quinine	Unenumerated, etc.
Glycerine, crude and refined	Iodine and iodine compounds

### ALKALIES

Soda ash	Soda crystals	Soda bicarbonates	Soda caustic
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### DYE-STUFFS AND INTERMEDIATES

Benzoic acid	Naphthol
Salicylic acid and salicylates	Anthracene dyes and alizarine
Aniline and other coal tar dyes	Indigo
Alizarine dyes	Acetanilid
Naphthol-naphthylamine	Aniline (aniline oil)
Naphthylamine	Aniline salts
Anthraquinone, nitrobenzol, toluidine, resorcin, phthalic acid and other coal tar products	

### TANNING EXTRACTS

Extract of oak	Extract of chestnut	Extract of sumac
pine	gallnut	quebracho

This report requires 113,400 tabulations, of which 97,200 have to be recomputed.

<sup>2</sup>Recent investigations have shown that paraffine oil is not so inactive as was supposed toward gases, and brine is better for the purpose of collecting flue gas samples.

## Imports and Exports

The following imports and exports for the month of December, 1918, are reported by the Special Statistical Service Section, Division of Statistics, Bureau of Foreign and Domestic Commerce, Department of Commerce:

### IMPORTS OF TUNGSTEN-BEARING ORE

Countries	Tons	Value	Countries	Tons	Value
Mexico	4	\$6,440	China	244	\$258,720
Argentina	42	66,243	Hongkong	526	571,451
Bolivia	25	33,825	Japan	12	18,218
Chile	100	133,525			
Colombia	35	42,700	Total	1,033	\$1,184,569
Peru	45	53,447			

### U. S. EXPORTS OF TUNGSTEN AND FERROTUNGSTEN METAL, BY COUNTRIES

Countries	Lb.	Value
Canada	2,000	\$4,400
Argentina	225	770
Total	2,225	5,170

### IMPORTS AND EXPORTS OF LEAD AND ZINC, BY COUNTRIES

IMPORTS:		Gross Weight	Contents,	
Articles and Countries	Lead Ore:	Tons	Lb.	Value
Canada		180	277,200	\$14,553
Mexico		11,618	153,185	7,407
British South Africa		526	259,529	20,892
Total		12,324	689,914	\$42,852
Lead Bullion and Base Bullion:				
Mexico		15,383,544	14,946,348	803,483
Zinc Ore and Calamine:				
Canada		1,172	932,866	19,082
Mexico		2,732	2,005,415	45,101
Total		3,904	2,938,281	64,183
FOREIGN EXPORTS:				
Lead, Pigs, Bars, and Old, total			671,227	\$45,206
DOMESTIC EXPORTS:				
Lead Pigs and Bars, product of domestic ore			4,441,279	368,980
Lead Pigs and Bars, product of foreign ore			6,411,949	437,060
Zinc Spelter Cast in Pigs, product of domestic ore			13,131,377	1,368,591
Zinc Spelter Cast in Pigs, product of foreign ore			3,272,856	263,711
Zinc, Rolled in Sheets, Strips, Etc.			3,861,040	488,122

### IMPORTS AND EXPORTS OF PLATINUM AND IMPORTS OF IRIIDIUM ETC., BY COUNTRIES

#### Imports of Platinum and Iridium

Countries	Ore and Unmanufactured Platinum		Ingots, Bars, Plates, Sheets, Wire, Etc., of Platinum		Vases, Retorts, Etc., of Platinum		Iridium, Osmium, Palladium, Etc.	
	Oz. (Troy)	Value	Oz. (Troy)	Value	Oz. (Troy)	Value	Oz. (Troy)	Value
England	27	\$2,928						
Canada	3	\$315	22	2,332			134	12,486
Panama			456	38,790				
Dominican Republic			3	214				
Colombia	2,418	217,183	1,147	101,680				
Venezuela	16	1,610						
Japan	1	156	98	12,587				
Australia							35	5,769
New Zealand							4	457
Total	2,438	\$219,264	1,753	\$158,531			174	\$18,835

#### Exports of Platinum

Country	Platinum Unmanufactured Oz. (Troy)	Platinum Manufactured Value
Canada		\$1,342

## Recent Chemical and Metallurgical Patents

**Making Pyroxylin Compounds.**—In attempting to substitute certain non-volatile liquids for camphor in pyroxylin compounds, it has hitherto been thought necessary to remove the water from the pyroxylin before combining with the liquids. WILLIAM G. LINDSAY of Newark, N. J., has made the interesting discovery that these liquids, if mixed with wet pyroxylin, remain in the mixture when the latter is subjected to pressure between bibulous pads, while the water is entirely eliminated from the press-cake. The resultant dried cake has all the valuable properties of camphor pyroxylin compounds. Liquids mentioned as being suitable for this purpose are: benzyl benzoate, tricresylphosphate, castor oil and mixtures such as camphor, 35 parts with triphenylphosphate, 65 parts; camphor and fusel oil. (1,292,819; assigned to the Celluloid Co.; Jan. 28, 1919.)

**Concentrating Nitric Acid.**—Mixed nitric and sulphuric acids, such as the mixtures resulting from nitration processes, are introduced at the top of a cylindrical brick lined steel tower, having a central opening filled with pieces of quartz. Steam admitted at the bottom of the tower vaporizes the nitric acid, while the water is retained to a very large extent by the sulphuric acid. The nitric acid vapors pass to a condenser, which is so arranged that the uncondensed vapors are led off to an absorption tower in which they react with water to form dilute nitric acid. This is returned to the first tower for concentration. When applied to mixtures containing not less than 64 per cent sulphuric acid and from 3 to 25 per cent nitric acid, the process yields a product which is 90 to 97 per cent  $\text{HNO}_3$ . (1,292,948; FRED C. ZEISBERG, assignor to E. I. du Pont de Nemours & Co.; Jan. 28, 1919.)

**Recovering Solvent From Colloided Nitrocellulose.**—The usual method of recovering ether and alcohol used as solvents for nitrocellulose in the manufacture of smokeless powder results in a loss of a certain percentage of the solvents, in spite of the fact that about fourteen days are required to complete the four operations necessary. A process, which recovers a higher percentage of the solvents in two days, has been devised by WILLIAM F. NASH of Kenil, N. J. The basic principle of the invention is the displacement of the ether by alcohol and the subsequent displacement of the alcohol by water. The apparatus consists of three tanks, which we will designate A, B and C. A and B are equipped with fractionating columns; B and C have steam coils. By means of suitable valves and connections, a single pump is able to circulate liquid either through tanks A and B, or all three in series, as desired. The nitrocellulose is placed in A and the ether displaced by circulating alcohol at 55 deg. C. from B through the guncotton, which is preferably in the form of pellets. The ether vapors pass through the fractionating column on A into the storage tanks. When the ether content of the pellets has been reduced to the proper value, the valve between the fractionating column on B and tank B is opened and

the liquid in B brought to the boiling point. The connections are now arranged in such a manner that the liquid from A passes to B, where the alcohol is vaporized and conducted through the column to the storage tank, while the liquid refluxed from the column is led into C, where a quantity of water equal to the alcohol distilled off is added. This diluted alcohol is kept at a temperature of from 50 to 55 deg. C. and is pumped to tank A, thus maintaining a constant circulation of liquid, the alcohol content of which is constantly diminishing. When the material in A has had enough solvent extracted to give the required residual solvent when dried, the circulating liquor is all collected in B and the remaining solvent fractionated off. The nitrocellulose is now dried in the usual manner. (1,293,515; assigned to Hercules Powder Co.; Feb. 4, 1919.)

**Refining Zinc Pigment.**—L. E. WEMPLE of St. Louis, Mo., proposes to remove compounds deleterious to the tinctorial properties and permanency of zinc pigments made from impure raw materials. He purposely makes a first fume containing zinc sulphate, finding that objectionable lead and cadmium oxides cannot exist in conjunction with such excess. This fume is then mixed with pulverized lampblack and roasted for 30 min. in a muffle hearth at between 900 and 1200 deg. F. By a combination of reactions, the carbon reduces the excess of zinc sulphate without attacking the lead and cadmium sulphates, eliminating any arsenic and antimony compounds at the same time. At the end of the required roast, stirring is continued during a quick cooling, when excess carbon is burned out, and  $\text{SO}_2$  and other occluded gases are largely eliminated. The method avoids coarsening of grain and recrystallization accompanying excessive heating and prevents the formation of objectionable carbonates. (1,292,976; assigned to American Zinc, Lead & Smelting Co.; Jan. 28, 1919.)

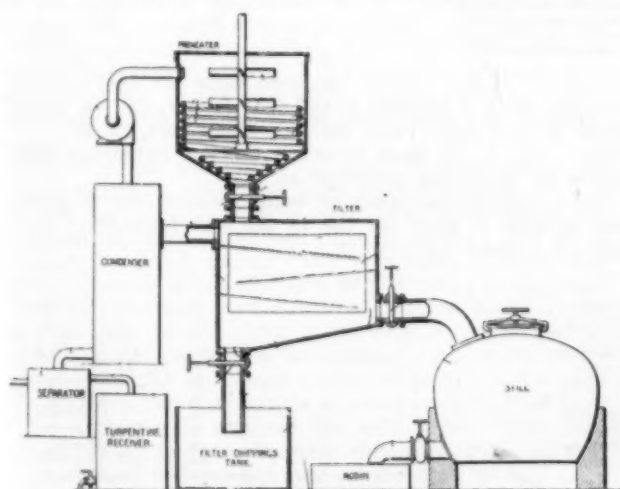
**Refining Nickel-Copper Matte.**—When bessemerized nickel-copper matte is ground to 60 mesh, roasted, reground, and heated with dilute  $\text{H}_2\text{SO}_4$  at 80 deg. C., some 70 per cent of the copper is dissolved, with a little of the nickel. CARL and OTTO SANGER, of Clydach, Wales, patent a further separation as follows: The filtered residue is then mixed with 140 Tw.  $\text{H}_2\text{SO}_4$  and heated at 150 deg. C. in cast iron pans, which converts the oxides into water-soluble sulphates. Copper in this solution is now precipitated quantitatively by finely divided metallic nickel, and the clear filtrate electrolyzed, producing copper-free nickel. (1,291,030; Jan. 14, 1919.)

**Manganese Steel.**—W. G. NICHOLS of Chicago proposes the following method to reuse manganese-steel scrap without great loss of manganese by oxidation or volatilization: Cold scrap, with or without additional 80 per cent ferromanganese, is charged into an electric furnace and heated carefully to about 600 deg. F., and maintained at that temperature until the non-conductive metal has a thoroughly equalized heat. Temperature is gradually raised, without the production of hot spots, until the whole is at 1200 deg. F., when a basic slag is added and a reducing atmosphere maintained so as to prevent loss in manganese. Gradually the temperature is raised to the



fusion point of the steel, and is kept without superheating until a short time before tapping. Such an alloy can be made into castings, or used as an addition to converter metal; in the latter case it is recommended that the highly heated blown metal be tapped, the slag skimmed off, the melt weighed, and a computed amount of molten manganese-iron alloy added, the latter formed as above and at a minimum pouring temperature. The resulting temperature of the mixture should then be such as to allow immediate teeming. (1,291,655 and 6; assigned to American Manganese Steel Co., Jan. 14, 1919.)

**Distillation of Crude Pine-Resins.**—In the manufacture of turpentine, the customary procedure of skimming the melted crude gum in the still prior to distillation is unsatisfactory. The smaller pieces of bark, chips, etc., remain in sufficient quantities to cause the discoloration of the resin during the distillation process, thereby lowering its value. The skimmings themselves are saturated with gum and contain undissolved lumps of gum. In addition to this, during the skimming process, vapors of turpentine escape from the open still, causing a further loss of valuable material. With these difficulties in mind, ROBSON DUNWODY of New Orleans has designed the improved system shown in the accompanying diagram. The crude gum is placed in the preheater and brought to a temperature not exceeding 200 deg. F., by means of the steam coils. It is then stirred vigorously to break up the lumps. Any vapors which are given off during the heating are drawn into the condenser by means of a suction fan. The gum is permitted to flow into the filter chamber, in which the coarser impurities and undissolved lumps of gum are removed



IMPROVED SYSTEM FOR DISTILLATION OF CRUDE PINE-RESINS

by a series of inclined screens of varying mesh. The sloping bottom of this chamber prevents the finer particles of sand, dirt, etc., from entering the still with the gum, which is now free from impurities and unstained, as the temperature at this stage is below that at which the impurities begin to discolor the gum. When a sufficient charge has collected in the still, the preheater valve is closed and the filter chamber drained. During the distillation, the hot vapors of turpentine pass through the filter box on their way

to the condenser and melt the gum contained in the material on the screens. This gum, which contains the coloring matter extracted from the impurities, collects in the bottom of the filter chamber, is drained off from time to time and, if desired, distilled independently. The turpentine, as it issues from the condenser, is led into a separator, in which the acid water known in the trade as low wine is removed. At the end of the run, the resin is run out into a receiver and the dry skimmings left on the screens in the filter box are removed and destroyed, as the values have been completely extracted. (1,291,800; Jan. 21, 1919.)

**Sintering Ores.**—In down draft sintering furnaces (such as Dwight-Lloyd machines) the charge becomes more porous as the flame works downward into the cake, thus allowing an undue excess of air to cut down the roasting efficiency of the machine. The best sintering results are apparently obtained by a slow-burning process, consequently A. H. RICHARDS of Garfield, Utah, proposes to add a fresh layer of ore so timed to intercept the accelerated roasting due to excess air. This layer is then ignited on its top, and the cake then is in two layers, burning independently. The process may be repeated as often as necessary, and if properly done, will produce a continuous, evenly sintered mass, at a high tonnage rate. (1,292,059; assigned to American Smelting & Refining Co., Jan. 21, 1919.)

**Roasting by Surface Combustion.**—C. D. McCOURT of London, England, patents the process of feeding a continuous stream of sized material through a suitable shaft, equipped with charging and discharging bells, and injecting into this column, through tuyeres, an explosive gaseous mixture. The speed of the blast must evidently be greater than the velocity of combustion. Temperatures considerably in excess of the ordinary result of such reactions may be had by the accelerated surface combustion. Fusing of the charge may be prevented by using a gaseous mixture of low calorific intensity, or increasing the speed with which the granular mass passes the tuyeres. Oxidizing, reducing, chloridizing or other atmospheres may be produced in this manner. (1,291,965; assigned to Surface Combustion, Inc., Jan. 21, 1919.)

**Sulphidizing Roasting.**—ARTHUR S. DWIGHT of New York City notes that many natural ores, for instance those of copper, are deficient in sulphur to the extent that after the volatile sulphur has been driven off in heating, not enough remains to form a matte and clean slag. By-products, such as zinc residues and burned pyrite, contain small amounts of valuable metals which could be recovered if properly sulphidized. He has discovered that if sulphur ores be pulverized and mixed with finely divided metals with a strong affinity for sulphur such as copper or iron and heated to a bright red heat, free oxygen being excluded, the unstable sulphur will unite with the metal instead of distilling. He therefore proposes to heat oxidized ores with sufficient carbon to effect the reduction of the metals, and then mix with a pulverized sulphur-bearing ore. The product becomes pasty at a comparatively low temperature, and can be delivered either in lumps for blast furnace work, or finely divided for reverberatory smelting. (1,238,279; Aug. 28, 1917.)

## Personal

MR. G. C. BENSON, recently of Nobel, Ont., Canada, has accepted a position with the National Carbide Co. of Toronto as research chemist.

MR. A. S. BLAGDEN has been elected president of the Air Reduction Co., Inc., New York, N. Y.

MR. E. C. CARLYLE has resigned his position as analytical chemist with the Geo. H. Morrill Co., Norwood, Mass., and become associated with the Saabach Laboratories, Inc., analytical and consulting chemists, New York.

MR. E. T. CASLER, formerly chemist for the Phosphate Mining Co., Nichols, Florida, is now chemist with the Air Nitrates Corp.

MR. WILLIS B. CLEMMITT has joined the engineering staff of the Powdered Coal Engineering & Equipment Co. of Chicago, Ill., in the capacity of advisory engineer. Mr. Clemmitt was formerly assistant superintendent of the open-hearth department of the Central Iron & Steel Co., Harrisburg, Pa.

MR. EDWARD S. DAVIS, chief of the Fuel Oil Section, Bureau of Oil Conservation, after six months of service, has returned to Tate, Jones & Co., Inc., Pittsburgh, Pa.

MAJOR A. C. FIELDNER, Chemical Warfare Service, U. S. A., who was in charge of the gas masks research at the American University Experiment Station, Washington, D. C., has returned to the Pittsburgh Station of the Bureau of Mines, where he will have charge of the chemical research laboratory.

DR. FEDERICO GIOLITTI, director general of the steel works of Giov. Ansaldo & Co., Italy, and of international note as a metallurgist, is now in the United States on business and is making his headquarters in New York City.

MR. C. W. JOHNSON has been appointed assistant manager of works of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

MR. ARTHUR LACHMAN is now connected with the Great Western Electro-Chemical Co., San Francisco, Calif.

CAPTAIN P. E. LANDOLT has resigned from the Nitrate Division, Ordnance Dept., U. S. A., and has returned to his old position as chemical engineer with the Research Corporation, New York City.

MR. H. L. OLIN is now chemist in the research department of The Barrett Company, Edgewater, N. J., having been discharged from the Army at Edgewood Arsenal, where he had the rank of Captain, C. W. S.

MR. SEELY B. PATTERSON, JR., formerly assistant general manager of the Bethlehem Steel Co.'s Cuban interests, has been relieved from duty in the Engineering Corps and is now in Allentown, Pa.

MR. WALTER H. PEARCE, for three years with the Commercial Research Company, New York and Flushing, N. Y., is now metallurgist with Paul G. Niehoff & Co., Chicago, Ill.

MR. GEORGE H. RUPPERT, who, before his entry into the Chemical Warfare Service, had charge of a sodium ferrocyanide department of the Semet-Solvay Co., has accepted a position as advisory engineer with the Powdered Coal Engineering & Equipment Co., Chicago, Ill.

MR. HERBERT L. SHERMAN, formerly president of the New England Bureau of Tests, Inc., and more recently in charge of inspection for the Construction Division of the United States Army, has become a member of the firm of Arthur D. Little, Inc., Cambridge, Mass.

MR. JOSEPH T. TERRY, JR., who for some time past has been engaged in conducting flotation experiments for the American Zinc Co., Mascot, Tenn., has opened an office as a consulting engineer under the title Terry Mining and Metallurgical Corp., at Salt Lake City, Utah.

MR. TAMOTSU WATANABE of Tokyo, Japan, is visiting the industrial centers of the United States in the interests of the Mogi Commercial & Industrial Department.

## Obituary

MR. HERBERT R. DRYFOOS, president of the Cleveland Alloys Co., Cleveland, Ohio, died on Feb. 18 at his home, of pneumonia.

LIEUT. ELBERT C. BAKER, the only son of J. T. Baker of the J. T. Baker Co., Phillipsburg, N. J., was killed in action Sept. 30, 1918. Lieut. Baker, a graduate of Cornell University, was engaged as a research chemist in his father's laboratory and during the one year of his employment was doing special work in standardizing methods of analysis for chemical reagents along the lines suggested by the Bureau of Standards.

## Current Market Reports

### The Non-Ferrous Metal Market

**Saturday, March 8.**—The non-ferrous metal prices are now on a peace basis with few exceptions, and an active market is expected.

**Aluminium:**—There is an open market for aluminium and conditions are quiet. Ingots 98-99 per cent are offered at 31c. Sheets, 18 gage and heavier, are 42c. Powder, 100 mesh, 70c.

**Antimony:**—Wholesale lots are offered from 7c. to 7½c. and jobbing at 7½c. There is no active buying.

**Copper:**—During the past ten days, 25,000,000 lb. of copper was sold at from 14½c. to 14¾c. per lb. The Government surplus stocks are to be turned back to the producers and a firm market is to follow from now on.

Copper sheets, hot-rolled.....	lb.	\$0.24
Copper sheets, cold rolled.....	lb.	.25
Copper bottoms.....	lb.	.32
Copper rods.....	lb.	.21
Copper wire.....	lb.	.19
High brass wire and sheets.....	lb.	.20
High brass rods.....	lb.	.19
Low brass wire and sheets.....	lb.	.22
Low brass rods.....	lb.	.23
Brass tubing.....	lb.	.31
Brass bronze tubing.....	lb.	.36
Seamless copper tubing.....	lb.	.31
Seamless bronze tubing.....	lb.	.31
Seamless brass tubing.....	lb.	.30
Bronze (gold) powder.....	lb.	1.00

**Lead:**—The lead market has been quiet but firm and indications point to activity in the near future. E. St. Louis quotes 5c. and New York, 5½c. lb. Sheet lead, 8c. lb.

**Tin:**—The U. S. Steel Products Co. has liquidated over half of its 10,000-ton allotment at 72½c.

**Zinc:**—Spelter has taken an extraordinary decline, going from \$134.50 to \$121 per ton in the last fortnight. Zinc dust, 14c. Sheet zinc, 11c. lb.

### OTHER METALS

Bismuth.....	lb.	\$3.20 — \$3.65
Cadmium.....	lb.	1.40 —
Cobalt.....	lb.	2.50 — 3.50
Magnesium.....	lb.	1.75 — 2.10
Mercury.....	75 lb.	75.00 —
Nickel.....	lb.	1.50 —
Nickel.....	lb.	.40 — .45
Tungsten.....	lb.	Nominal
Iridium.....	oz.	175.00 —
Palladium.....	oz.	115.00 —
Platinum.....	oz.	97.50 — 100.00
Silver.....	oz.	1.01 —

### The Iron and Steel Market

War-time prices for steel are about to be deflated as a result of the operation of a plan devised by Secretary of Commerce Redfield and approved by the President. For this purpose the Industrial Board of the Department of Commerce has been organized, with George N. Peek, formerly vice-chairman of the War Industries Board, as chairman. At a meeting of representatives of the iron and steel industry held in New York March 6, Mr. Peek outlined the plan and it was unanimously approved. The next proceeding is the meeting between the board and a committee of the industry, to be held in the week beginning March 17. The reduced schedule of prices may be announced immediately after that meeting, but more likely further time will be required for negotiation and study of conditions.



The Government's object is to deflate prices, particularly prices of commodities involved in building operations. The operation is based on the dictum that "the law of supply and demand cannot cure what it did not create," this being a system of controlled prices for war time, set high for the purpose of stimulating production. When there is no buying, the law of supply and demand does not operate. This is a fact that the steel industry has frequently exemplified, for in periods of light demand it has refrained from reducing prices, maintaining that reduced prices would not stimulate buying.

It is recognized on all hands that the resumption of construction work depends upon the action of no one industry, and that all prices entering into construction work must come down in order to make the proposition attractive to the investor. Accordingly, while the Industrial Board begins with the iron and steel industry, it gives assurance that it will take up all building materials and some other materials as well. No program is mapped out for the distant future, and it is intimated, if not promised, that the activities will be discontinued whenever it is seen that the law of supply and demand is again operating. The proposition is welcomed by the iron and steel industry, though the industry does not advertise the fact, because it affords the opportunity that otherwise might be lacking for making a formal reduction in prices and establishing a level to which individual producers will be disposed to adhere. Without some such formality the iron and steel producers would have the opportunity of adhering to existing prices or nothing and naturally they would choose the former.

#### INDUSTRY ACTIVE

Up to this writing the iron and steel industry has, as a whole, experienced no hardships that would make it desirable to reduce prices radically. There has been a very remarkable situation. With practically all branches of the iron and steel market very dull, and with almost all consuming industries presenting the appearance of decided inaction, the production of steel has been very heavy. In proportion to capacity, assumed at 49,000,000 gross tons per annum, production of steel ingots in January was at 85.1 per cent, while production in February was at 83.6 per cent, this statement being predicated upon the trustworthy returns of the American Iron and Steel Industry, covering the monthly output of 29 companies which in 1917 made more than 87 per cent of the country's total output. Production at this writing is but little below the February average.

While it is marvelous that the steel industry should operate at so high a rate, with trade very dull, it is a corollary that nothing like such a rate could be continued for any length of time. In normal times more than half of all the steel produced passes into construction work and scarcely anything along this line is now being undertaken. A peculiar combination of circumstances has made it that there has been an outlet for a remarkable large quantity of steel. Ingot production in February was at the rate of about 40,900,000 gross tons a year, while in no year prior to the war was there an output as great as 31,000,000 tons, and the highest rate attained, for only a few weeks, was about 35,000,000 tons, in the early spring of 1913. At that time much steel was passing into construction work.

While the industries of the country are regarded as relatively inactive, there are some exceptions. The automobile industry is working at top speed, and while it has not yet attained the quantity production of which it is capable the necessary shop changes are nearing completion and materials and accessories are being assembled. The Ford Motor Co., for instance, which originally planned to reach an output of 3000 a day by June 1, has already attained 2500 and expects to reach 3000 by April 1. Steel shipments to the automobile industry are the heaviest on record. In nearly all the oil and gas fields there is great activity and the demand for the "oil country goods" of the pipe mills is fully up to normal. The agricultural implement factories are fairly busy, but in this case no large demand for steel is involved, as the factories had very considerable stocks. Altogether, however, it is difficult, if not impossible, to ex-

plain in full where the large steel production has been going.

#### PIG IRON DECLINES

In pig iron there has not been the same incentive for maintaining prices as has existed in the case of finished steel products. In the latter there is always a clear cut market, the price being uniformly f.o.b. Pittsburgh plus freight to destination. In pig iron the normal condition is for each district to have its own market, there being many districts, including Alabama, Virginia, eastern Pennsylvania, Buffalo, Cleveland, Chicago and "the valleys"—Mahoning and Shenango. War time control placed all furnaces, irrespective of location, on precisely the same basis, and then last September produced a still more curious alignment by putting Virginia on a Birmingham basis and eastern Pennsylvania on a Pittsburgh basis. As this alignment would certainly be departed from some time, the furnaces have had no great incentive to maintain it. The recommendation of the industry's committee last December, prepared for submission to the War Industries Board but refused consideration by the board because it was about to disband, was that a reduction of \$3 be made in pig iron. This recommendation was eventually adopted by the furnaces, but since the beginning of this month there have been some recessions. A Birmingham interest, for instance, cut the recognized price of \$31, Birmingham, on No. 2 foundry by \$2.75 on an order for 500 tons, establishing \$28.25 as the price to be shot at next. At least two eastern Pennsylvania furnaces resumed quoting on the basis of furnace, instead of f.o.b. Pittsburgh, effecting declines averaging about \$2 a ton in delivered prices. Two or three valley furnaces, on quite moderate tonnages, quoted \$28, furnace, or less, for No. 2 foundry, or \$3 under the previously recognized market. Buffalo furnaces adhered to \$31, Buffalo furnace, for local trade, but one interest circularized distant markets offering iron on a lower basis. In basic and bessemer no definite declines occurred, possibly because there was no inquiry.

Resale ferromanganese has been available at \$150, f.o.b. shipping point, for 80 per cent, against makers' nominal quotations of \$200, delivered, for 80 per cent and \$170 for 70 per cent. The last established market was \$250 for 70 per cent.

There has been only occasional and inconsequential shading of steel prices by producers. Orders have been small individually, and more likely to be placed at full prices than at concessions, for the average buyer once in receipt of a cut price quotation would be moved, not to place the order, but to seek further concessions.

#### The Chemical Market

**COAL TAR PRODUCTS:**—The character of trading in coal tar products has shown little change during the interval, although there seems to have been more inquiries for the various products and producers are looking forward to a resumption of some activity. The textile industry is recovering from its recent slackness and as it is an accepted fact that this has a strong bearing on the color market, this is the best proof for the possibilities of intermediates developing a more firm position in the market. In the meantime, however, small lot transactions continue to feature the market and lower price levels have generally been effected.

**Benzol:**—The consuming demand for this product seems to be steady, although the various directions report stocks in sufficient quantities to take care of additional business. Producers have lowered their prices 2c. per gallon for tank car material and the reduction also applies to that in drums.

**Phenol:**—The weak position of the market that has been evident for some time continues and accumulations of large quantities of the product are noted in various directions. Most producers of the product have closed down their plants and some are buying back their own product at low levels to complete their unfilled contracts.

**Toluol:**—Resale offerings of this product seem to create some buying interest, but from all accounts second hands

seem to have little to offer. Manufacturers report a fair business passing and prices are firmly maintained.

**Naphthalene:**—The market for the various varieties of this product has undergone no important changes, with no disposition on the part of buyers to purchase beyond their immediate needs and even the drug trade, which is quite a factor at this season of the year, has seemingly not brought its full requirements to the market.

**Alpha Naphthol:**—Offerings of this product are none too liberal; however, there is no pressure on the part of buyers and no difficulty is experienced in meeting the situation. Prices are firmly maintained for both the crude and refined products.

**Aniline Oil:**—Another slight reduction in prices has been made by manufacturers of this commodity, who seemingly have accumulated fair quantities of stocks. While a fairly steady business is reported, individual sales noted are of a minor character.

**Aniline Salt:**—A steady sale is reported, but there has been no resumption of any important activities in the demand, and available stocks are more than sufficient for the current call. Prices, however, are quotably unchanged.

**Alpha Naphthylamine:**—Prices for this material are steady at the recent decline, but supplies are large enough to cause some concern on the part of producers, while buyers are apparently not interested in any forward stocks.

**Benzidine:**—There has been nothing in the way of any increase in business for this material and the recent export activity for the base product seems to have eased off, while the sulphate variety appears to be entirely neglected.

**Cresol:**—Trading continues along quiet lines; however, business is of sufficient volume to avoid any accumulation of stocks, with available supplies generally in proportion to the current call. Dealers have not altered their recent prices, which are firmly maintained.

**Diethylaniline:**—Trading in this product has been somewhat more active, which was seemingly brought about by some reductions in prices on the part of manufacturers, and transactions for the most part seem to be direct, with little trading noted through second hands.

**Metanitraniline:**—The market for this material is without special feature and small lot trading continues to constitute the only activity at the moment. However, there is no accumulation of stocks in any important quantity, and prices for the commodity are firmly maintained.

**Metaphenylenediamine:**—The continued quietness for this product has had its effect and price reductions in most directions are noted, with available supplies more than sufficient for the current call.

**Diphenylamine:**—Consumption requirements are in no important quantities and there seems to be a fair accumulation of stocks in the various directions, but holders have not altered their recent quotations since the recent decline; however, it is intimated on a firm order some concessions would be made.

**Dinitrophenol:**—There is little in the way of any important trading for this material and prices seem to be firmly maintained in most directions, although some large lot business was consummated where prices shading was effected.

**Dinitrobenzol:**—No material changes have developed in this market; trading is of a routine nature and individual sales are confined to small lots. Despite the quietness prevailing manufacturers are firmly maintaining prices.

**HEAVY CHEMICALS:**—While no important volume of trading overshadowed the market, there seems to have been more export orders about, but this activity was brought to a sudden standstill when the labor strike along the waterfronts was announced. Under these circumstances exporters were not disposed to bring their orders to the market, in view of the possibility of goods being left on docks and subject to other hazardous conditions. On the other hand, local trading continues along quiet lines, with consumers confining their purchasing to immediate needs, expecting lower price levels, but it is an accepted fact that manufac-

turing costs will not be much lower, especially as to wages, which proportionately reflects in the actual selling prices of many commodities. Most of the business is transacted through second hands, where competition is keen and price cutting is general when there seems to be some actual business at hand, but small lot trading constitutes the only activity in any direction. Caustic soda has attracted little attention on the part of buyers; stocks are seemingly plentiful and the market is rather weak, while the position of soda ash is more firm at the recent decline.

**Soda Ash:**—The consuming trade seems to be steadily taking a fair portion of supplies, which tends to keep the market rather steady for bag material. Single bags from the warehouse are now quoted at \$1.55 to \$1.65 by second hands. Barrels are offered at \$1.85 ex-warehouse per 100 lb., although some cheap lots seem to be available at most times at \$1.75. Double bags at Middle Western shipping points are held at \$2.15 to \$2.25, with offerings at similar prices at the Pacific Coast.

**Caustic Soda:**—There has been little interest noted on the part of buyers, who seem to be in a position to close in lots of ten to twenty tons at favorable prices, while round lots would be difficult to close at much less than 3c. per lb. for the 76 per cent solid, despite the fact that limited quantities are freely offered at 2½c. to 3c. per lb. Ground caustic seems to be gradually easing off, with offerings made at 3½c. to 4c. by second hands.

**Cyanide of Soda:**—Prices for this commodity are firmly maintained, although there is no unusual activity noted and trading seems to be confined to small lots. Purchasing is generally direct, with the 96-98 per cent material being quoted at 30c. to 31c., while the chloride mixture of 73-76 per cent is held at 25c. to 27c. and the chloride carbonate mixture is quoted at 20c. to 21c.

**Chlorate of Soda:**—No improvement has been noticed in the call for this product, which appears to be in liberal supply and prices are quotably unchanged ranging from 18c. to 20c.

**Chlorate of Potash:**—The demand is steady and trading is of sufficient volume to keep the market firm, particularly for the domestic product, which seems to be the most preferable. Prices are steady at 40c. per lb. f.a.s., while the Japanese powdered material is offered at 32c. to 33c. and the crystals at 30½c. to 31½c., according to quantity.

**Yellow Prussiate of Soda:**—The item continues to be neglected, with no disposition on the part of buyers to purchase forward stocks.

**Bichromate of Soda:**—The position of this item in the market appears to be gradually weakening, with prices fractionally declining from time to time. First hands quote from 12c. to 12½c. for spot material with resale offerings being made at from 11½c. to 12c., and sales are reported to be passing at the inside figures in most instances.

**Copper Sulphate:**—There has been no resumption of any important trading in this commodity and purchasing seems to be confined to immediate needs. Standard brands of the 98-99 large crystals are now offered at 7½c. to 8c., while the medium crystals are held at from 7½c. to 7¾c. for spot material.

**Magnesia Calcined:**—While consumption requirements seem to be of sufficient volume to keep the high-grade product well sold up, other varieties are apparently more liberal in supply. In most instances, the high-grade light variety is quoted at from 70c. to 75c. for early April delivery, and the medium grade is held at 40c. to 50c., with the heavy variety being offered at from 9c. to 10c.

**Yellow Prussiate of Potash:**—Small lot trading continues to feature the market and reports from the various directions indicate stocks are in liberal supply. In some instances, in the resale market, there are offerings as low as 55c., with others quoting 58c. to 60c.

**Red Prussiate of Potash:**—There seems to be little in the way of actual trading in this material and supplies are in sufficient quantity to take care of additional business. Prices for the material are steadily declining, with offerings now held at \$1.50 to \$1.60.



## General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 8, 1919

Acetic anhydride.....	lb.	.90	1.00
Acetone.....	lb.	.15	.16
Acid, acetic, 28 per cent.....	cwt.	3.25	3.50
Acetic, 56 per cent.....	cwt.	6.50	6.75
Acetic, glacial, 99 1/2 per cent, carboys.....	cwt.	14.00	14.50
Boric, crystals.....	lb.	.13	.13
Citric, crystals.....	lb.	1.25	1.27
Hydrochloric, (22%).....	cwt.	2.50	3.00
Hydrofluoric, 30 per cent, in barrels.....	lb.	.08	.08
Lactic, 44 per cent.....	lb.	.14	.15
Lactic, 22 per cent.....	lb.	.06	.07
Molybdic, C. P.....	lb.	6.90	7.40
Nitric, 36 deg.....	lb.	.07	.07
Nitric, 42 deg.....	lb.	.08	.10
Oxalic, crystals.....	lb.	.35	.36
Phosphoric, 47-50 per cent paste.....	lb.	.07	.10
Phosphoric, ref. 50 per cent.....	lb.	.26	.30
Picric.....	lb.	.50	.75
Pyrogallol, resublimed.....	lb.	2.90	3.20
Sulphuric, 60 deg. works.....	ton	12.00	14.00
Sulphuric, 66 deg. works, tank cars.....	ton	19.00	21.00
Sulphuric, oleum (fuming), tank cars.....	ton	25.00	26.00
Tannic, U. S. P., bulk.....	lb.	1.40	1.50
Tartaric, crystals.....	lb.	.84	.85
Tungstic, per lb. of W.....	lb.	1.70	1.75
Alcohol, sugar cane, 188 proof.....	gal.	4.85	4.85
Alcohol, wood, 95 per cent.....	gal.	1.22	1.24
Alcohol, denatured, 180 proof.....	gal.	.40	.42
Alum, ammonia lump.....	lb.	.04	.05
Alum, chrome ammonium.....	lb.	.17	.18
Alum, chrome potassium.....	lb.	.20	.22
Alum, chrome sodium.....	lb.	.12	.13
Alum, potash lump.....	lb.	.09	.10
Aluminium sulphate, technical.....	lb.	.02	.02
Aluminium sulphate, iron free.....	lb.	.03	.03
Ammonia aqua, 26 deg., carboys.....	lb.	.07	.08
Ammonia, anhydrous.....	lb.	.30	.35
Ammonium carbonate.....	lb.	.13	.14
Ammonium nitrate.....	lb.	.16	.17
Ammonium sulphate, domestic.....	lb.	.05	.05
Amyl acetate.....	gal.	3.75	4.25
Arsenic, white.....	lb.	.09	.10
Arsenic, red.....	lb.	.35	.40
Barium carbonate, 99 per cent.....	ton	80.00	90.00
Barium carbonate, 97-98 per cent.....	ton	65.00	67.00
Barium chloride.....	ton	65.00	75.00
Barium sulphate (blanc fixe, dry).....	lb.	.03	.04
Barium nitrate.....	lb.	.10	.11
Barium peroxide, basis 70 per cent.....	lb.	.30	.32
Bleaching powder, 35 per cent chlorine.....	lb.	.01	.02
Borax, crystals, sacks.....	lb.	.08	.08
Bromine, crude.....	ton	65.00	70.00
Bromine, technical.....	lb.	.65	.65
Calcium acetate, crude.....	lb.	.04	.05
Calcium carbide.....	lb.	.06	.08
Calcium chloride, 7-75 per cent, fused, lump.....	ton	18.00	22.00
Calcium peroxide.....	lb.	1.50	1.70
Calcium phosphate.....	lb.	.22	.23
Calcium sulphate, 98-99 per cent.....	lb.	.09	.09
Carbon bisulphide.....	lb.	.07	.08
Carbon tetra-chloride, drums.....	lb.	.14	.15
Carbonyl chloride (phosgene).....	lb.	.75	1.00
Caustic potash, 88-92 per cent.....	lb.	.50	.60
Caustic soda, 76 per cent.....	100	2.75	2.95
Chlorine, liquid.....	lb.	.10	.12
Cobalt oxide.....	lb.	1.60	1.65
Copperas.....	lb.	.01	.02
Copper carbonate.....	lb.	.31	.32
Copper cyanide.....	lb.	.65	.70
Copper sulphate, 99 per cent, large crystals.....	lb.	.07	.08
Cream of tartar, crystals.....	lb.	.55	.58
Epsom salt, bags, U. S. P.....	100	2.75	2.75
Formaldehyde, 40 per cent.....	lb.	.22	.23
Glauber's salt.....	lb.	.02	.02
Glycerine, bulk, C. P.....	lb.	.17	.18
Iodine, resublimed.....	lb.	4.25	4.30
Iron oxide.....	lb.	.06	.08
Lead acetate, white crystal.....	lb.	.14	.15
Lead arsenate (paste).....	lb.	.15	.18
Lead nitrate, C. P.....	lb.	.85	.86
Litharge, American.....	lb.	.10	.11
Lithium carbonate.....	lb.	1.50	1.50
Magnesium carbonate, technical.....	lb.	.16	.17
Nickel salt, single.....	lb.	.14	.15
Nickel salt, double.....	lb.	.12	.13
Phosgene (see carbonyl chloride).....	lb.	.75	1.00
Phosphorus, red.....	lb.	.75	.80
Phosphorus, yellow.....	lb.	.50	.60
Potassium bichromate.....	lb.	.37	.38
Potassium bromide, granular.....	lb.	1.25	1.26
Potassium carbonate, calcined, 85-90 per cent.....	lb.	.21	.25
Potassium chlorate, crystals.....	lb.	.40	.41
Potassium cyanide, 98-99 per cent.....	lb.	2.50	2.75
Potassium iodide.....	lb.	3.75	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.....	ton	270.00	285.00
Potassium nitrate.....	lb.	.26	.30
Potassium permanganate, U. S. P.....	lb.	.95	1.05
Potassium prussiate, red.....	lb.	1.50	1.60
Potassium prussiate, yellow.....	lb.	.55	.58
Potassium sulphate, 90-95 p. c. basis 90 p. c.....	ton	Nominal	Nominal
Rochelle salt.....	lb.	.46	.48
Salammoniac, gray gran.....	lb.	.14	.16
Salammoniac, white gran.....	lb.	.13	.15
Salt soda.....	100	1.60	1.70
Salt cake.....	ton	18.00	20.00
Silver cyanide, based on market price of silver.....	oz.	.62	.63
Silver nitrate.....	oz.	1.55	1.60
Soda ash, 58 per cent, light, flat (bags).....	100	3.05	3.15
Soda ash, 58 per cent, dense, flat.....	100	.12	.13
Sodium acetate.....	lb.	.02	.02
Sodium bicarbonate, domestic.....	lb.	.12	.14
Sodium bicarbonate, English.....	lb.	.05	.07
Sodium bichromate.....	lb.	.18	.20
Sodium bisulphite, powd.....	lb.	.30	.31
Sodium chlorate.....	lb.	.14	.15
Sodium cyanide.....	lb.	.14	.15
Sodium fluoride, commercial.....	lb.	.14	.15

Sodium hyposulphite.....	100	3.25	3.75
Sodium molybdate, per lb. of Mo.....	lb.	2.50	2.50
Sodium nitrate, 95 per cent.....	100	4.07	4.13
Sodium nitrite.....	lb.	.13	.14
Sodium peroxide.....	lb.	.25	.30
Sodium phosphate.....	lb.	.04	.04
Sodium prussiate, yellow.....	lb.	.22	.24
Sodium silicate, liquid (60 deg.).....	lb.	.04	.04
Sodium sulphide, 30 per cent, crystals.....	lb.	.02	.02
Sodium sulphide, 60 per cent, fused.....	lb.	.04	.05
Sodium sulphite.....	lb.	.05	.06
Strontium nitrate.....	lb.	.25	.30
Sulphur chloride, drums.....	lb.	.07	.09
Sulphur dioxide, liquid, in cylinders.....	lb.	.12	.15
Sulphur, flowers, sublimed.....	100	3.05	3.15
Sulphur, roll.....	100	2.70	3.10
Sulphur, crude.....	ton	35.00	35.00
Tin bichloride, 50 deg.....	lb.	.25	.26
Tin oxide.....	lb.	.65	.70
Zinc carbonate.....	lb.	.18	.20
Zinc chloride.....	lb.	.14	.14
Zinc cyanide.....	lb.	Nominal	Nominal
Zinc dust, 350 mesh.....	lb.	.12	.13
Zinc oxide, American process, works.....	lb.	.10	.12
Zinc sulphate.....	lb.	.04	.06

## Coal Tar Products (Crude)

Benzol, pure, water white.....	gal.	.20	.25
Benzol, 90 per cent.....	gal.	.25	.25
Toluol, in tank cars.....	gal.	.25	.25
Toluol, in drums.....	gal.	.30	.35
Xylol, pure, water white.....	gal.	.45	.55
Solvent naphtha, water white.....	gal.	.20	.25
Solvent naphtha, crude, heavy.....	gal.	.15	.17
Cresote oil, 25 per cent.....	gal.	.45	.55
Dip oil, 20 per cent.....	gal.	.35	.40
Pitch, various grades.....	ton	8.00	20.00
Carbolic acid, crude, 95-97 per cent.....	lb.	Nominal	Nominal
Carbolic acid, crude, 50 per cent.....	lb.	Nominal	Nominal
Carbolic acid, crude, 25 per cent.....	lb.	Nominal	Nominal
Cresol, U. S. P.....	lb.	.18	.20

## Intermediates, Etc.

Alpha naphthol, crude.....	lb.	1.00	1.10
Alpha naphthol, refined.....	lb.	1.50	1.60
Alpha naphthylamine.....	lb.	.45	.48
Aniline oil, drums extra.....	lb.	.24	.25
Aniline salts.....	lb.	.36	.40
Anthracene, 80 per cent.....	lb.	.50	.55
Benzaldehyde (f.f.c.).....	lb.	2.50	2.60
Benzidine, base.....	lb.	1.25	1.40
Benzidine, sulphate.....	lb.	1.15	1.25
Benzoic acid, U. S. P.....	lb.	1.45	1.55
Benzoate of soda, U. S. P.....	lb.	1.30	1.50
Benzyl chloride.....	lb.	.50	.50
Beta naphthol benzoate.....	lb.	5.50	6.00
Beta naphthol, sublimed.....	lb.	.75	.85
Beta naphthylamine, sublimed.....	lb.	2.50	2.55
Dichlorobenzol.....	lb.	.15	.20
Diethylaniline.....	lb.	2.25	2.75
Dinitrobenzol.....	lb.	.30	.35
Dinitrochlorobenzol.....	lb.	.30	.35
Dinitronaphthalene.....	lb.	.50	.55
Dinitrotoluol.....	lb.	.40	.50
Dinitrophenol.....	lb.	.38	.40
Dimethylaniline.....	lb.	.55	.60
Diphenylamine.....	lb.	.70	.75
H-acid.....	lb.	2.35	2.75
Metaphenylenediamine.....	lb.	1.55	1.75
Monochlorobenzol.....	lb.	.15	.17
Naphthalene, flake.....	lb.	.08	.09
Naphthalene, balls.....	lb.	1.00	1.10
Naphthionic acid, crude.....	lb.	1.20	1.30
Naphthylamine-di-sulphonic acid.....	lb.	1.00	1.10
Nitro naphthalene.....	lb.	.40	.45
Nitro toluol.....	lb.	.55	.60
Ortho-amidophenol.....	lb.	6.00	7.00
Ortho-dichlor-benzol.....	lb.	.15	.20
Ortho-toluidine.....	lb.	.45	.50
Ortho-nitro-toluol.....	lb.	.65	.70
Para-amidophenol, base.....	lb.	3.25	3.65
Para-amidophenol, H. C. L.....	lb.	3.50	3.75
Para-dichlor-benzol.....	lb.	.15	.20
Paranitraniline.....	lb.	1.30	1.35
Para-nitro-toluol.....	lb.	1.50	1.60
Paraphenylenediamine.....	lb.	3.25	3.50
Para toluidine.....	lb.	1.80	1.85
Phthalic acid anhydride.....	lb.	2.50	3.00
Phenol, U. S. P.....	lb.	Nominal	Nominal
Resorcin, technical.....	lb.	4.50	5.00
Resorcin, pure.....	lb.	7.00	8.00
Salicylic acid, U. S. P.....	lb.	.50	.55
Salol.....	lb.	.95	1.00
Sulphanilic acid, crude.....	lb.	.25	.31
Toluidine.....	lb.	2.45	2.55
Toluidine-mixture.....	lb.	.80	1.00

## Petroleum Oils

Crude (at the Wells)

Pennsylvania.....	bbl.	4.00	4.00
Corning, Ohio.....	bbl.	2.85	2.85
Somersot, Ky.....	bbl.	2.60	2.60
Weseter, Ohio.....	bbl.	2.80	2.80
Indiana.....	bbl.	2.28	2.28
Illinois.....	bbl.	2.25	2.25
Oklahoma and Kansas.....	bbl.	2.25	2.25
Caddo, La., light.....	bbl.	2.20	2.25
Coriscana, Tex., light.....	bbl.	2.25	2.25
California.....	bbl.	1.24	1.57
Gulf Coast.....	bbl.	1.25	1.25
Mexican.....	bbl.	1.90	1.90
Fuel Oil			
New York.....	gal.	.15	.15
Philadelphia.....	gal.	.10	.10
Baltimore.....	gal.	.07	.15
Pittsburgh.....	gal.	.07	.10
Texas.....	bbl.	1.85	2.35
Los Angeles.....	bbl.	1.65	1.65

## Gasoline (Wholesale)

New York, motor	gal.	.24	—
Gas machine	gal.	.41	—
72-76 degrees	gal.	.33	—
70-72 degrees	gal.	.32	—
67-70 degrees	gal.	.30	—
Pittsburgh, motor	gal.	.25	—
Chicago, motor	gal.	.21	—
Oklahoma, motor	gal.	.23	—
San Francisco, motor	gal.	.20	—

## Paraffine Waxes

Crude, 103 to 105 deg. m.pt.	lb.	.08	—
Crude, 118 to 120 deg. m.pt.	lb.	.09	—
Crude, 124 to 126 deg. m.pt.	lb.	.10	—
Refined, 120 deg. m.pt.	lb.	.12	—
Refined, 128 deg. m.pt.	lb.	.14	—
Refined, 135 deg. m.pt.	lb.	.16	—
Ozokerite, brown	lb.	.75	—
Ozokerite, green	lb.	.85	—

## Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.23	—
Cylinder, light	gal.	.42	—
Cylinder, dark	gal.	.39	—
Paraffine, high viscosity	gal.	.40	—
Paraffine, 0.903 sp. gr.	gal.	.33	—
Paraffine, 0.885 sp. gr.	gal.	.26	—

## Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.58	—
Pine oil, destructively distilled	gal.	.58	—
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.23	—
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.23	—
Wood creosote, ref., f.o.b. Florida	gal.	.31	—

## Naval Stores

Rosin A-E barrel	280 lb.	12.20	—
Rosin F-I	280 lb.	12.45	—
Rosin K-N	280 lb.	13.50	—
Rosin WG-W	280 lb.	15.35	—
Spirits of turpentine	gal.	.69	—
Wood turpentine, steam distilled	gal.	.64	—
Wood turpentine, destructively distilled	gal.	.63	—
Pitch	220 lb.	8.00	—
Tar, kiln dried	280 lb.	13.00	—
Retort tar	280 lb.	14.00	—
Rosin oil, first run	gal.	.74	—
Second run	gal.	.76	—
Third run	gal.	.82	—
Fourth run	gal.	.92	—

## Vegetable Oils

Castor oil	lb.	.21	—
China woodoil	lb.	.20	—
Cocanut oil	lb.	.12	—
Corn oil	lb.	.13	—
Cottonseed oil, crude	lb.	.17	—
Linseed oil, raw, cars	gal.	1.50	—
Palm	lb.	.18	—
Peanut oil, crude	lb.	.14	—
Soya bean oil, Manchuria	lb.	.12	—

## Glues

Extra white	lb.	.31	—
Cabinet	lb.	.25	—
Brown foot stock	lb.	.15	—
Fish glue, 50-gal. barrels	gal.	1.00	—

## Miscellaneous Materials

Barytes, floated, white domestic	ton	33.00	—
Beeswax, white, pure	lb.	.63	—
Beeswax, unbleached	lb.	.43	—
Blanc fixe	lb.	.05	—
Casoin	lb.	.17	—
Chalk, light, precipitated, English	lb.	.04	—
China clay, imported, lump	ton	20.00	—
China clay, domestic, lump	ton	15.00	—
Feldspar	ton	8.00	—
Fluorspar, gravel, f. o. b. mines	ton	28.00	—
Fluorspar, washed, powdered	ton	90.00	—
Fuller's earth, powdered	100 lb.	1.50	—
Graphite Alabama	lb.	.08	—
Ceylon	lb.	.09	—
Madagascar	lb.	.10	—
Mexican	ton	35.00	—
Japan wax	lb.	.18	—
Orange shellac	lb.	.72	—
Pumice stone	lb.	.04	—
Soapstone	ton	15.00	—
Stearic acid	lb.	.17	—
Talc, American, white	ton	20.00	—

## Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	100.00	—
Chrome cement	net ton	65.00	—
Clay brick, first quality fireclay	per 1000	40.00	—
Clay brick, second quality	per 1000	35.00	—
Magnesite, raw	ton	30.00	—
Magnesite, calcined, powdered	ton	50.00	—
Magnesite, dead burned	net ton	38.00	—
Magnesia brick, 9x4x2	net ton	90.00	—
Silica brick	per 1000	45.00	—

## Ferroalloys

Ferrocobaltitium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y.	ton	200.00	—
Ferrocobaltium	lb.	15.00	—
Ferrocobaltium, per lb. of Cr	lb.	30.00	—
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—
Spiegelisen (16-18%)	ton	57.00	—
Ferromolybdenum, per lb. of Mo	lb.	3.50	—
Ferrosilicon, 50 per cent, contract	ton	120.00	—
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal	—
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—
Ferrovanadium, f.o.b. works	lb.	—	—

## Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—
Coke	ton	6.00	—
Petroleum coke	ton	16.00	—
Manganese ore, 48 per cent and over, per unit	ton	1.20	—
Manganese ore, chemical	ton	80.00	—
Molybdenite, per lb. of MoS <sub>2</sub>	lb.	.80	—
Tungsten, Scheelite, per unit of WO <sub>3</sub>	ton	Nominal	—
Tungsten, Wolframite, per unit of WO <sub>3</sub>	ton	Nominal	—
Uranium oxide, 96%	lb.	3.25	—
Vanadium pentoxide, 99%	lb.	10.50	—
Pyrites, foreign	unit	.17	—
Pyrites, domestic	unit	—	—

## Plant Supplies

## BUILDING MATERIALS

Common clay bricks	M	14.00	—
Faced brick	M	37.00	—
Hollow tile, 4x12x12	M	56.00	—
Hollow tile, 12x12x12	M	162.00	—
Lime	ton	17.50	—
Portland cement	bbbl.	3.45	—
Single glass (82-lb.), 10x26-16x24	ton	21.00	—
Double glass (164 lb.), 10x26-16x29	ton	31.00	—
Yellow pine lumber	M	39.00	—
Cypress	M	70.00	—
Tarred felt (14-lb. sq.)	ton	52.00	—
Roofing pitch	ton	18.00	—
Asphalt coated roofing (35-55-lb. sq.)	sq.	1.60	—
Slate surfaced asphalt shingles	sq.	5.25	—
Corrugated galvanized iron	ton	109.00	—
Putty	100 lb.	6.25	—
Red oxide (Ppte. Coppina)	100 lb.	15.00	—
Native red oxide	100 lb.	3.25	—
Red metallic paint	100 lb.	1.20	—
White lead in oil	100 lb.	15.00	—
White lead (dry)	100 lb.	11.00	—
Red lead in oil	100 lb.	12.28	—
Red lead (dry)	100 lb.	14.50	—
Zinc oxide (dry)	100 lb.	13.00	—
Zinc oxide—leaded	100 lb.	9.00	—
Yellow ochre	100 lb.	1.50	—
Ultra marine blue	100 lb.	14.00	—
Prussian blue	100 lb.	135.00	—
Chrome green	100 lb.	40.00	—
Paris green	100 lb.	43.00	—
Mineral black	100 lb.	1.75	—
Powdered bone black	100 lb.	5.50	—
Lampblack	100 lb.	15.00	—
Gas carbon	100 lb.	16.00	—
Mexican petroleum pitch	100 lb.	1.00	—
Gilsonite	100 lb.	2.00	—
Coal tar pitch	100 lb.	.60	—

## STRUCTURAL IRON

Blue annealed sheet iron	ton	77.00	—
Black sheet iron	ton	90.00	—
Galvanized iron	ton	101.00	—
Tern plate, 13-lb. coating	ton	145.00	—
Tern plate, 25-lb. coating	ton	175.00	—
Tern plate, 40-lb. coating	ton	230.00	—
Tin plate, prime	ton	147.00	—
Tank plates	ton	60.00	—
Beams, channels, angles, T's, Z's	ton	56.00	—
Rivets	ton	88.00	—
Steel pipe, 1 to 3-inch	ton	51.00	—
Bar iron and steel	ton	60.00	—
Chain (1 inch proof coil)	ton	150.00	—
Nails, bolts, nuts, washers	ton	70.00	—
Tool steel, special alloys	ton	300.00	—
Bessemer pig iron	ton	32.00	—
Bessemer steel	ton	43.50	—
No. 2 foundry	ton	37.90	—
Steel billets (4 x 4)	ton	47.50	—

## POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—
Asbestos, high pressure	lb.	1.76	—
Asbestos, wired	lb.	1.30	—
Asbestos, graphited braid	lb.	1.21	—
Asbestos, wick	lb.	.75	—
Rubber, sheet	lb.	.66	—
Cup grease	lb.	.07	—
Transmission grease	lb.	.07	—
Axle grease	lb.	.04	—
Gear grease	lb.	.04	—
Cotton waste	lb.	.08	—
Hose, underwriters, 2 1/2 in.	ft.	.75	—
Hose, air, 1 in.	ft.	.50	—



# INDUSTRIAL

Financial, Construction and Manufacturers' News

## Construction and Operation

### Alabama

**BIRMINGHAM**—The Birmingham Railway Light & Power Co., 2100 1st Ave., has awarded the contract for the installation of new gas making machinery, to the Gas Machinery Co., 1900 Euclid Ave., Cleveland, Ohio. Estimated cost, between \$75,000 and \$80,000. The company plans to construct an addition to its gas house. J. S. Pevear, general manager.

**CHICKASAW**—The Tennessee Coal, Iron & Railroad Co. plans to build two ore smelters on its property here, to take care of ore brought from Cuba by the United States Steel Corporation.

### California

**SAN DIEGO**—Olmsted & Gillette, engineers, 1112 Hollingsworth Bldg., have submitted report to city on sewage disposal plant. Plans include the construction of intercepting sewers to cost \$320,000; small pumping station, \$32,500; screening plant, \$225,000, screens at 32nd St. plant, \$25,000; pumps at 32nd St. plant, \$4000. A. H. Wright, city clerk.

### Colorado

**TELLURIDE**—The Tomboy Gold Mines Co., Ltd., plans to build a new flotation plant and is in the market for lumber and flotation equipment. Estimated cost, \$150,000. D. A. Herron, general manager.

**VANADIUM**—The Primos Chemical Co. will rebuild its mill recently destroyed by fire, entailing a loss of \$100,000.

### Connecticut

**HAMDEN** (New Haven P. O.)—The town has been authorized to issue \$100,000 bonds for the construction of sewers and a sewage disposal plant.

### District of Columbia

**WASHINGTON**—The Bureau of Yards & Docks, Navy Department, has awarded the contract for the construction of a laboratory at the Naval Hospital here, to W. E. Mooney, Evans Building. Estimated cost, \$16,000.

**WASHINGTON**—The Bureau of Yards & Docks, Navy Department, has awarded the contract for installing mechanical equipment in hygienic laboratory in the South Building to J. E. Granberry, Fendal Building. Estimated cost, \$53,224.

### Florida

**JACKSONVILLE**—The Board of Commissioners of Duval Co. will soon award the contract for furnishing approximately 1500 gallons of arsenical cattle dip, delivered f.o.b., Jacksonville, in such quantities and at such times as may be directed by the County Purchasing Agent.

**ST. PETERSBURG**—The city has awarded the contract for installing sanitary sewers and two 1-story Cameron septic tanks in the northeastern section of the city to the Southern Construction Co., St. Petersburg. Total estimated cost, \$21,395. F. M. Nelson, city engineer.

**TAMPA**—The McElroy Engineering Co., Giddens Building, will soon receive bids for the construction of a sugar mill and farm, including 20 miles tramway. Estimated cost, \$800,000. Owner's name withheld.

### Georgia

**SAVANNAH**—The Reliance Fertilizer Co., 106 Bay St., plans to build a fertilizer plant. Estimated cost, \$100,000. Lockwood Greene & Co., Healey Building, Atlanta, engineer.

### Illinois

**CHICAGO**—The Armour Soap Works, 21st and Benson Sts., plans to build an addition to its distilling plant. Estimated

cost, \$35,000. R. C. Clark, architect, care owners, is receiving bids.

**CHICAGO**—The Municipal Tuberculosis Sanitarium, Crawford and Bryn Mawr Ave., will soon award the contract for the construction of a 2-story, 57 x 123.8 ft. laboratory and connecting tunnel, including sterilizing, serum and operating rooms, etc. Total estimated cost, \$75,000. J. Hunt, 30 North Michigan Ave., architect.

**EAST ST. LOUIS**—The Obea Nestor Glass Co., Broadway and Terminal R.R., has awarded the contract for rebuilding part of its factory destroyed by fire, to Ferdinand Ganschinitz, 501 North 18th St. Estimated cost, \$65,000.

**LINCOLN**—The Illinois China Co. will build a 5-kiln pottery plant, and install kilns and drying shed. A. Smith, manager.

**WOODRIVER**—The Board of Education will install equipment for the chemical and physical laboratory in the 2-story, 90 x 150 ft. high school which it plans to build. Total estimated cost, \$90,000. J. W. Kennedy, Cahokia Bldg., East St. Louis, Engr.

### Indiana

**FT. WAYNE**—The city plans to build a dam, filtering and purifying plant, having a capacity of 12,000,000 gals. Estimated cost, \$500,000. H. W. Becker, clerk of the board of public works. C. H. Hurd, 807 Merchants Bank Building, Indianapolis, engineer.

**HAMMOND**—The city plans to build a water filtration plant. W. Bridge, city engineer.

### Iowa

**HURON**—The Board of Education will receive bids until March 20 for the construction of a 2-story, 60 x 72 ft. high school building, including laboratories, auditorium, etc. Estimated cost, \$50,000. N. Schrock, Oakville, president. H. C. Eckland & Co., McKinnie Building, Moline, Ill., architect.

### Maryland

**BALTIMORE**—The City Water Department plans to build a new filtration plant, having a capacity of 120,000,000 gals. per day, as an addition to the existing filtration plant at Lake Montebello, which has a capacity of 128,000,000 gals. per day; also construct experimental filters for comparing the efficiency of mixing coagulants at the Montebello filters. W. E. Lee, City Water Engr.

**CURTIS BAY** (Baltimore P. O.)—The Mexican Petroleum Co., 120 Broadway, New York City, N. Y., plans to build a large refinery here. Estimated cost, \$1,000,000.

### Missouri

**ST. LOUIS**—The J. C. Finck Mineral & Milling Co., 101 Barton St., will build a 2-story, 78 x 105 ft. addition to its barytes milling plant. Estimated cost, \$8,000. C. P. Delore, engineer.

**ST. LOUIS**—Gerst Bros. Meat Co., 3823 Lucky St., has awarded the contract for the construction of a lard rendering and cooling plant to Gillespie & Day Co., International Life Building. Estimated cost, \$20,000.

**ST. LOUIS**—The Monsanto Chemical Co., 2nd and Lafayette Sts., will build a 1-story, 62 x 176 ft. factory at 102 Lafayette St. Estimated cost, \$20,000. L. Veillon, 2nd and Lafayette Sts., engineer.

### Nebraska

**LINCOLN**—The city plans an election April 8 to vote on a \$100,000 bond issue for the construction of 4½ miles of collecting and intercepting sewers and sewage disposal plant. A. Dobson, 945 D St., engineer.

### Michigan

**THREE RIVERS**—The Eddy Paper Co., White Pigeon, plans to build a new plant here. Estimated cost, \$1,750,000.

### New Jersey

**MILLTOWN**—The Elizabethtown Water Co., 48 Broad St., Elizabeth, plans to build

a pumping station and filter house near here. M. Sherrerd, engineer.

**NEW BRUNSWICK**—The Eastern Potash Co., 120 Broadway, New York City, N. Y., will build a potash plant here consisting of ten buildings. Estimated cost, \$2,000,000.

### New York

**BATH**—The County Dairymen's League will install laboratory equipment and an ammonia system in the dairy plant which it plans to build here. Total estimated cost, \$150,000. M. W. Davison, director.

**NEW YORK**—Frank Dowling, borough president, has awarded the contract for furnishing and delivering 40,000 gals. of gasoline to the Tidewater Oil Co., 11 Broadway. Estimated cost, \$9800.

**BROOKLYN**—The State Hospital Commission, Capitol, Albany, received bids Feb. 19 for building a sewerage disposal plant at the Brooklyn State Hospital, here, from Murphy Bros., 262 Bay 43rd St., Brooklyn, \$22,483 (200 days); L. F. Kelly, Inc., 296 Stuyvesant Ave., Brooklyn, \$22,540 (200 days); J. L. Sigretto & Co., 455 Woodhaven Ave., Woodhaven, \$23,000 (200 days). Noted Feb. 15. The contract was awarded to Murphy Bros.

**CHITTENANGO**—The Building Commission of the Dairymen's League will install laboratory equipment in the modern milk handling plant which it plans to build. Estimated cost, \$20,000.

**CORTLAND**—The Dairymen's Local League will install laboratory equipment in the modern milk plant which it plans to build here. Estimated cost, \$50,000. W. F. Webb, president.

**ROCHESTER**—The Dairymen's League plans to install laboratory equipment in the milk handling plant which it plans to build for the city. Total estimated cost, \$150,000. G. M. Tyler, president.

**TUCKAHOE**—The Hodgeman Rubber Co. plans to build a 1-story, 50 x 150 ft. factory. W. L. Stoddard, 9 East 40 St., New York City, architect.

**UTICA**—The State Hospital Commission, Capitol, Albany, received bids March 4 for the construction of a 2-story, 44 x 60 ft. laboratory and mortuary at the State Hospital here, from La Porte & Goodman, Albany, \$23,900; J. Gleason, Ilion, \$26,970; Kimberly Construction Co., Mayro Building, \$28,573. Noted Feb. 15.

**WILLARD**—The New York State Hospital Commission plans to build a chlorinating plant at the Willard State Hospital here. F. L. Warne, steward; L. F. Pilcher, Capitol, state architect.

### North Carolina

**WILMINGTON**—Morris & Co., 38 South Dearborn St., Chicago, Ill., plans to build a fertilizer factory on a site recently purchased here.

### Ohio

**CLEVELAND**—The Reflex Ignition Co., 1705 Payne Ave., has increased its capital stock from \$100,000 to \$250,000 and plans to build an 80 x 160 ft. plant.

**SILVER LAKE** (Bellefontaine P. O.)—The village plans an election soon to vote on a \$26,000 bond issue for the construction of a sewage disposal plant. E. A. Tewksbury, clerk.

**SPRINGFIELD**—The city plans to build a sewage disposal plant.

### Oklahoma

**DUNCAN**—The city will soon receive bids for the installation of new machinery for the sewage disposal plant. Estimated cost, \$10,000. Benham Engineering Co., Colcord Building, Oklahoma City, engineer.

**OKLAHOMA CITY**—The Magnolia Petroleum Co., 212 Oklahoman Building, will soon award the contract for the construction of a 1-story gasoline refinery. L. H. Bailey, 1214 North Oklahoma St., architect.

### Oregon

**MOLALLA**—The Molalla Fire Clay Co. plans to build a 1-kiln pottery factory on a 32-acre site, northwest of here, recently donated by the city. B. S. Sinoheimer, secretary.

### Pennsylvania

**CLARENDON**—The Tiona Refining Co. plans to rebuild its plant here recently destroyed by fire.

**HUNTINGDON**—The borough has retained Gannett, Seely & Fleming, Engr., 204 Locust St., Harrisburg, to make a detailed study, report and plans for complete

rehabilitation and purification of the borough water supply. A filter plant will probably be built.

**MANHEIM**—The U. S. Asbestos Co. plans to build a 1-story, 50 x 100 ft. and 50 x 200 ft. addition to its plant, to provide for increased capacity.

**PHILADELPHIA**—The Babies Hospital of Philadelphia, 1126 Walnut St., will install a chemical laboratory in the 7-story, 41 x 91 ft. hospital which it plans to build on 7th and Delancey Sts. Total estimated cost, \$80,000. C. A. Ziegler, Bailey Bldg., architect.

**PHILADELPHIA**—Powers, Weightman & Rosengarten, 916 Parrish St., have awarded the contract for the construction of a 4-story, 28 x 40 ft. factory for the manufacture of chemicals, to R. C. Ballinger & Co., 218 North 13th St. Estimated cost, \$30,000.

**TEMPLE**—The Temple Malleable Iron & Steel Co. has awarded the contract for the construction of a 1-story, 340 x 380 ft. plant near the Schuylkill Division of the Pennsylvania R.R., to F. D. Chase, People's Gas Building, Chicago, Ill. Plans include the installation of a chemical laboratory to use electro-metallurgical process. Total estimated cost, \$350,000.

**WILKES-BARRE**—S. T. Romberger Co., Franklin Junction, plans to build a 2-story, 24 x 30 ft. rendering plant. Estimated cost, \$10,000. C. Wannenwesch & Co., 563 Williams St., Buffalo, N. Y., architect.

### South Dakota

**HILL CITY**—The American Tin Mining Co. is in the market for a Teismith gyratory crusher, a Hardinge conical ball mill, three Richards pulsator classifiers, one settling cone, an electric furnace, two oil storage tanks and other equipment. Estimated cost, \$21,000.

### Texas

**WACO**—The Riverside Oil & Refinery Co., Oklahoma City, Okla., plans to build an oil refinery having a daily capacity of 1500 bbl.

**RANGER**—The city plans to build a distilled water plant. Estimated cost, \$10,000. W. M. Powell, manager.

### Virginia

**NORFOLK**—R. T. Lipscombe, 34 Virginia National Bank Building, and others plan to build a dehydration, ice and cold storage plant. Estimated cost, \$225,000. B. Mitchell, Seaboard Bank Building, architect.

### West Virginia

**CLARKSBURG**—The Clarksburg Water Board has awarded the contract for the construction of an addition to the mechanical filtration plant to the American Water Softener Co., 1011 Chestnut St., Philadelphia, Penn. Noted Mar. 4.

**MARTINSBURG**—The city plans to build sewerage system to include a sewage disposal plant. T. W. Sparrow, city engineer.

### British Columbia

**VANCOUVER**—The Tudhope Electric Metals, Ltd., has awarded the contract for the construction of a smelting plant to M. P. Cotton, 1537 Matthews St.

### Saskatchewan

**REGINA**—The City Council plans to install a filtration and softening plant for the city's water supply.

### Ontario

**CONISTON**—The Mond Nickel Co. will make improvements to its plant and install additional machinery. C. V. Corliss, manager.

**NORWAY**—The city plans to build a sewage disposal plant. Estimated cost, \$45,000. J. Brown, engineer.

**WELLAND**—The Maple Leaf Milling Co., Ltd., will rebuild its mill recently destroyed by fire. R. Cooper, manager.

### Quebec

**EAST ANGU**—The Brompton Pulp & Paper Co. plans to build an addition to its plant. Estimated cost, \$60,000. D. I. Spence, 246 Beaver Hall, Montreal, architect.

**VERDUN**—The city is having plans prepared by A. E. Coby Sons, engineers, City Hall, for improving and enlarging the waterworks and filtration plants. Estimated cost, \$200,000.

## Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold a meeting in Buffalo, April 7 to 11.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its annual meeting in New York City from April 3 to 5.

THE INTERNATIONAL MINING CONVENTION will be held in Vancouver, B. C., Canada, March 17-19.

THE NATIONAL FOREIGN TRADE COUNCIL will hold its sixth National Foreign Trade Council at the Congress Hotel, Chicago, Ill., on Thursday, Friday and Saturday, April 24, 25 and 26, 1919.

THE SOCIETY OF INDUSTRIAL ENGINEERS plans a national conference at New York March 18-21 at the Hotel McAlpin, at which there will be a discussion of labor by both employers and labor leaders. Internal plant organization and also the elimination of fatigue will be other leading topics.

## Manufacturers' Catalogs

DE LAVAL STEAM TURBINE Co., Trenton, N. J., has issued a 32-page catalog describing standardized geared turbine units for marine service. The gain in fuel economy of the steam turbine over the reciprocating engine is stated to be approximately 25 per cent. The geared turbine weighs about half as much and occupies less than a third of the cubical space required by the engine. It is also more accessible and easier to repair, the expense for supplies and attendance is considerably less. The new publication describes the details of construction of turbines and gears and also various turbine-driven auxiliaries, including lighting sets, circulating pumps, boiler feeders, etc. A new development is the centrifugal pump for the continuous purification of the oil used in the turbine and gear bearings and on the gear teeth.

THE CRESCENT BELT FASTENER Co., 381 Fourth Ave., New York, wants all interested companies to take advantage of the bulletin and service chart entitled "Why People Buy Crescent Belt Fasteners," which may be obtained upon request.

THE WALTER A. ZELNICKER SUPPLY Co., St. Louis, Mo., has just issued Catalog No. 259, on new and used tanks.

THE LAKEWOOD ENGINEERING Co., Cleveland, Ohio, calls attention to Bull. No. 25, which shows the Lakewood line of storage battery tractors and trucks for all kinds of industrial haulage. On page 14 is an unusual table giving the type of trailers recommended for different classes of work, which is based on actual tests. Another interesting feature is the standardization of a few types of trailers instead of making a great number of different designs, which results in the higher development of each standard trailer.

WILSON WELDER & METALS Co., INC., New York, has just received from the press a catalog entitled "Repair of the German Ships," which was the biggest welding repair job in the history of the world. Many interesting illustrations are given showing cylinders before and after welding.

THE BROWN HOISTING MACHINERY Co., Cleveland, Ohio: Catalog K 1919 illustrates and describes in 96 pages Brownhoist locomotive cranes. This attractive catalog deals with buckets, capacities of cranes, clearances of cranes, coal and coke handling, construction work, 3-5 and 30-40 ton cranes, dock, dragline, electric, excavating, foreign and gasoline-driven cranes, lumber handling, magnet work, orange-peel, ore handling, pile drivers, portal-pier, sand handling, shipbuilding, special cranes, stone handling, wharf cranes and work-car cranes.

THE EASTMAN KODAK Co., Rochester, N. Y., has just issued a price list of Eastman organic chemicals.

THE CHAS. A. SCHIEREN Co., New York City, has recently received from the press a price list which differentiates the various brands of Schieren beltings not only by name and marking but also by grades and weights. This is a valuable feature to the buyer, as it enables him to select by name a Schieren belting which will meet his specifications, and he will know exactly what to expect when ordering by name. It also obviates, to a great extent, chances of the buyer selecting a belting largely upon a price basis, as the specifications show what can be expected of the various brands, in actual service. In other words,

while the detail specifications enable the buyer to select a brand of belting best suited for his service, these same specifications also tend to keep him from selecting a brand which would not do his work satisfactorily. This company has also issued an attractive catalog entitled "The Story of Schieren Beltings," which is really a textbook on the leather belting business, and is handy for a reference book. The business of tanning hides and manufacturing the leather into belting is treated in a thorough manner, step by step, and many illustrations are given, in colors.

THE CUTLER-HAMMER MFG. Co., Milwaukee, Wis., is distributing the 1919 edition on wiring device written in Spanish, which has 24 pages. It lists and illustrates the majority of the C-H wiring devices shown in the 1919 English catalog. We have also received the catalog on C-H Wiring Devices, Push Button Specialties (written in English), which gives in 64 pages a description and a list of push sockets, switches, a table listing conduit fittings made by eleven manufacturers, interchangeable plugs and receptacles, automobile lighting switches and control switches.

## Stocks and Bonds

Closing Bid and Asked Quotations Mar. 12, on N. Y. Stock Exchange

N. Y. Stock Exchange					
CHEMICAL COMPANIES					
	Bid	Ask		Bid	Ask
Am. Ag. Ch.	105 1/2	106	Mat. Al. Wk.	28	44
do. pf.	100	102	Ten. C. & C.	12 1/2	14
Barrett Co.	122	123	Un. Dyewood	55	61
do. pf.	113	115	do. pf.	90	95
Gen. Chem.	170	185	Va.-Car. Ch.	57 1/2	58
do. pf.	103	106	do. pf.	111 1/2	112 1/2
Int. Ag. Ch.	15	16 1/2			
do. pf.	60	60 1/2			

Bonds			
	Bid	Ask	
Am. Ag. Ch., 1st cv. 5s, '28	97	99 1/2	
Am. Ag. Ch., cv. db. 5s, '24	104	106	
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32	80	80 1/2	
Va.-Car. Ch., 1 mtg. 5s, '23	95 1/2	96	
Va.-Car. Ch., cv. db. 6s, '24	101	101 1/2	

PETROLEUM COMPANIES					
	Bid	Ask		Bid	Ask
Asso. Oil Co.	74	74 1/2	P-A Pet & Tr	82 1/2	83 1/2
Cal. Pet.....	27 1/2	27 3/4	do. pf.....	144	145
do. pf.....	74 1/2	74 3/4	Pierce Oil.....	17 1/2	18
Col. G. & E.	45 1/2	46	Royal Dutch.	95	95 1/2
Mex. Pet.....	186 1/2	187	Sinclair O & R	36 1/2	36
do. pf.....	106	110	Texas Co.....	207	207 1/2
Ohio Cit. Gas	38 1/2	38 3/4	Tex. Pac. Ld.		285
do. pf.....	45 1/2	46	Tr.....	245	285
Ohio Fuel S.	45 1/2	46	Tidewater Oil	221	223
Okla. P. & R.	8 1/2	8 3/4			

Bonds			
	Bid	Ask	
Columbia Gas & Electric, 1 1/2s, '27	80	85	
Col. G. & E., std. 1 1/2s, '27	81	84	
Pan-Am. Pet. & Tr., 1 1/2s, '19-'27	130		
Pierce Oil, cv. db. 6s, '24	92 1/2	92 3/4	
Pierce Oil, cv. 5s, Notes, '20	100	101	
Sin. O & R, 1 in. 7s, '20, with atk. war.	94	100	
Sin. O & R, 1 in. 7s, '20, without atk. war.	96 1/2	96 3/4	
Texas Co., db. 6s, '31	102 1/2	103	
Union Oil of Cal., 1 1/2s, '31	93	94	
United Fuel Gas, 1 mtg. 6s, ser. A, '36	95	96	

IRON AND STEEL SECURITIES					
	Bid	Ask		Bid	Ask
Am. St. F.....	86	86 1/2	Pitts. Stl. pf.	90	98
Beth. Steel.....	66 1/2	67	Rep. Iron &		
do. class B.....	66 1/2	67	Steel.....	82 1/2	83
do. pf., 8 1/2s, 104s	104 1/2	104 3/4	do. pf.....	102 1/2	104
do. pf., 7 1/2s, 90s	98	98 1/2	Sloss Sheff. I.		
Central Fdry.....	17	21	& S.....	56 1/2	57
do. pf.....	34	36	do. pf.....	86	90
Col. F. & I.....	41 1/2	41 3/4	Superior Steel	36	38 1/2
do. pf.....	108	125	do. 1 pf.....	92	102
Cruc. Steel.....	67 1/2	67 3/4	Trans. & W.		
do. pf.....	94 1/2	100	Steel.....	38 1/2	39 1/2
Great No. Ore	43 1/2	44	Un. Alloy St.	41 1/2	41 3/4
Gulf Sta. Steel	57	59	U.S.C.I.P. & F.	19	20
do. 1 pf.....	96	98	do. pf.....	52	53 1/2
Lack. Steel.....	70 1/2	70 3/4	U. S. Steel	96 1/2	96 3/4
Mid. St. & Ord	46 1/2	46 3/4	do. pf.....	114 1/2	115
Nova Scotia			Va. Coal, I & C	58	60
Steel.....	49	51			

Bonds			
	Bid	Ask	
Beth. Steel, 1 ext. gtd. S.F. 5s, '26	96	96 1/2	
Beth. Steel, 1 in. ref. 5s, Ser. A, '42	89	89 1/2	
Beth. Steel, P. M. & I. S. F. 5s, '36	82 1/2	83	
Buff. & Susq. Iron, 1 S. F. 5s, '32	91	96	
Buff. & Susq. Iron, deb. 5s, '27			
Cent. Found., 1 mtg. S. F. 6s, '21			
Col. F. & I., gn. S. F. 5s, '43	89	90	
Ill. Steel, db. 4 1/2s, '40	83	84 1/2	
Ind. Steel, 1 mtg. gtd. 5s, '32	97	98	
Lack. Steel, 1 1/2s, '23	96 1/2	97 1/2	
Lack. Stl., 1 con. mtg. cv. 5s, Ser. A, '50	87	89	
Mid. St. & Ord., cit. cv. S. F. 5s, '36	86 1/2	86 3/4	
Nat. Tube, 1 mtg. gtd. 5s, '52			
Rep. I. & S. F. mtg. 5s, '40	95 1/2	96 1/2	
Tenn. C. & I. R.R., gn. 5s, '51	92	95	
U. S. Steel, S. F. 5s, '63	100	100 1/2	
Va. C., I. & C., 1 1/2s, '49	87 1/2	89 1/2	